COMPARISON OF VERSION 5 AND VERSION 4

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AIRS Science Team Meeting

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Version 5 Changes from Version 4

- New AIRS RTA (Larrabee Strow)
  - Accounts for Non-LTE
  - Requires smaller tuning coefficients
- Time dependent CO_2 initialization
  - CO_2 uncertainty term allows for removal of AIRS physics error term
- New regression coefficients
  - Improved treatment of surface emissivity
  - Cloudy regression using observed AIRS radiances
    - With (and without) AMSU radiances
- Reduced cloud clearing and cloud parameter retrieval channel set over land
  - Does not use channels that see the surface
- New temperature sounding channels
  - Tropospheric temperature sounding uses only 4 μm channels
- New sequence of steps
- Empirical error estimates
  - Used for Level 2 and Level 3 quality control
- AIRS only retrieval system Version 5 AO
  - Version 5 AO does not use AMSU A observation

Steps in Version 4 and Version 5 Level 2

Version 4

MIT AMSU Retrieval

Gives X^{MIT}, q_{liq}, surf class

AMSU Retrieval using X^{MIT}

Gives $X^{microwave} = X^0$

Determine $\hat{R}_i^0, \alpha^0, P_c{}^0$ using X^0

Determine X^{reg} from $\hat{R}_i^0$

AMSU retrieval gives X^1

Determine $\hat{R}_i^1$ using X^1

Physical retrieval updates T_s

AMSU retrieval (using T_s fixed) gives X^2

Determine $\hat{R}_i^2$ using X^2

Physical retrieval using $\hat{R}_i^2$ gives X^{PHYS}

AMSU retrieval using X^{PHYS} gives $X^{3,test}$

$\hat{R}_i^3$ determined from $X^{3,test}$

Physical retrieval using $\hat{R}_i^3$ gives X^{final}

Select X^0 or X^{final}

Clouds, OLR determined from X^0 or X^{final}

Do QC

Not in Version 5

Version 5

MIT AMSU Retrieval

Gives X^{MIT}, q_{liq}, surf class

Cloudy regression gives X^{CR} (= X^0 in AO)

AMSU Retrieval using X^{CR}

Gives $X^{microwave} = X^0$

Determine $\hat{R}_i^0, \alpha^0, P_c{}^0$ using X^0 (X^{CR} in AO)

Determine X^{reg} from $\hat{R}_i^0$

AMSU retrieval gives X^1

Determine $\hat{R}_i^1$ using X^1 (X^{reg} in AO)

Physical retrieval using $\hat{R}_i^1$ gives X^{PHYS}

AMSU retrieval using X^{PHYS} gives $X^{3,test}$

$\hat{R}_i^2$ determined from X^{PHYS}

Physical retrieval using $\hat{R}_i^2$ gives X^{final}

Select X^0 or X^{final}

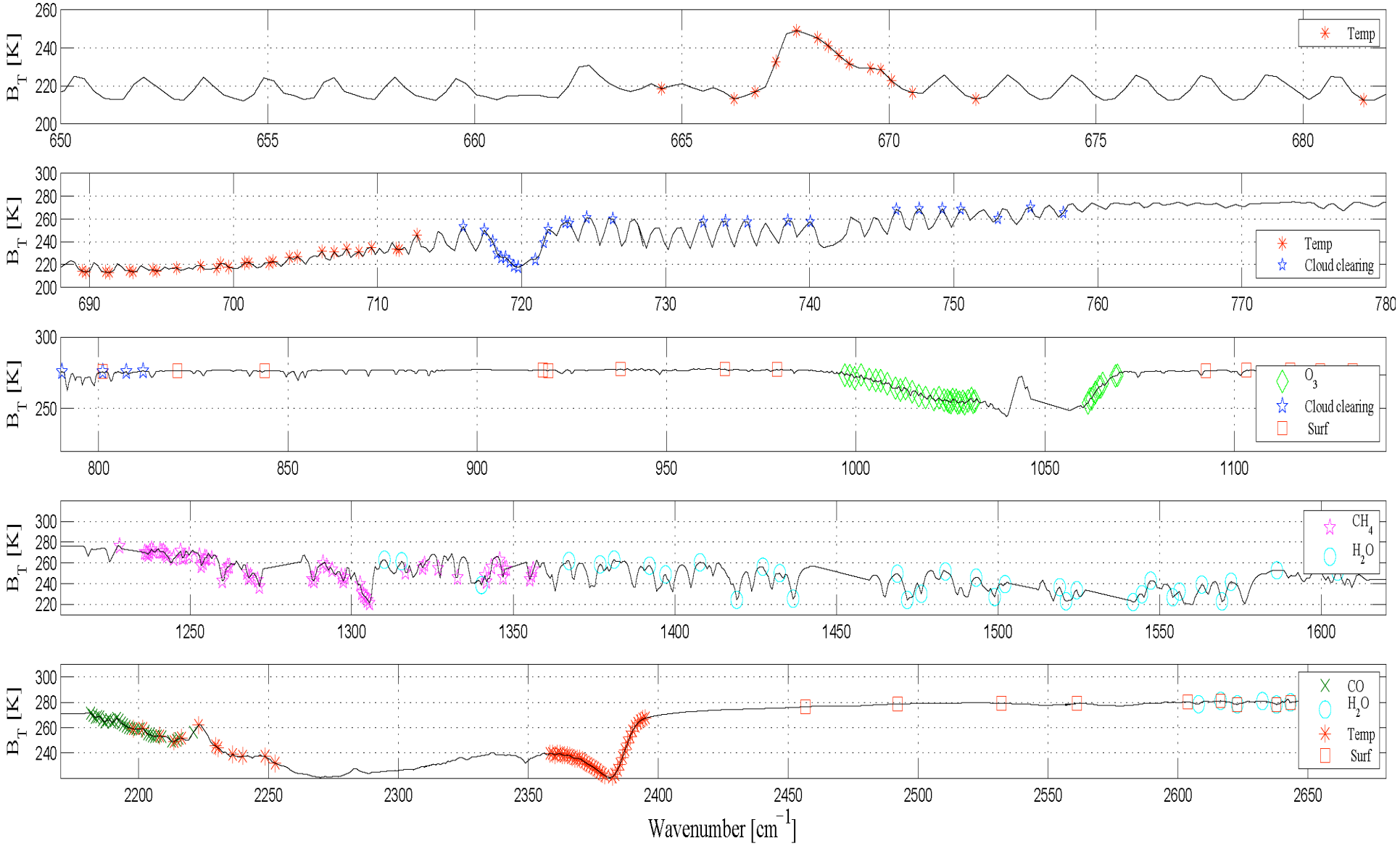
Clouds, OLR determined from X^0 or X^{final}

Generate error estimates δX

Do QC

Not in Version 5 AO

Version 5.0 Channels



GENERATION OF EMPIRICAL ERROR ESTIMATES δX_i

This step is done after physical retrieval is otherwise completed

Methodology used for $\delta SST, \delta T(p)$ is identical

Uses 16 internally computed values of convergence tests Y_j (13 in V5 AO)

Thresholds of 12 Y_j terms are used in Version 4 quality control

δX_i, error estimate for X_i, is computed according to

$$\delta X_i = \sum M_{ij} Y_j$$

Determination of M_{ij}

Use profiles with "truth"

$$\Delta X_i = \left| X_i - X_i^{TRUTH} \right|$$

Each profile now has $\Delta X_i, Y_j$

M_{ij} found which minimizes RMS $\left| \delta X_i - \Delta X_i \right|$

M_{ij} generated using all September 29, 2004 cases in which IR retrieval is accepted

ECMWF taken as "truth" to provide ΔX_i

M_{ij} tested on January 25, 2003 - used once and for all

Same basic approach is used for $\delta \hat{R}_i, \delta q(p)$

METHODOLOGY USED FOR VERSION 5 QUALITY CONTROL

Temperature Profile T(p)

Define a profile dependent pressure, p_g, above which the temperature profile is flagged as best

Use error estimate $\delta T(p)$ to determine p_g

Start from 70 mb and set p_g to be the pressure at the first level below which

$\delta T(p) >$ threshold for n (currently = 3) consecutive layers

Temperature profile statistics include errors of T(p) down to p = p_g

Thresholds are different for land, non-frozen ocean

Sea surface temperature SST

Flag SST as best if $\delta SST < 0.8K$ (tight test), good if δSST between 0.8K and 1.0K (standard test)

Clear column radiance $\hat{R}_i$

Consider $\hat{R}_i$ as best if $\delta \hat{R}_i < 0.9K$ in brightness temperature error units (no flag)

The data assimilation user can select different thresholds if they so choose

QUALITY FLAGS

QC = 0 (Best) QC = 1 (Good) QC = 2 (Do not use)

Use for data assimilation Use for Level 3

Temperature Profile

Version 5

QC T(p) = 0 if $p \leq p_g$

QC T(p) = 1 over land if $p \geq p_g$ and $p_g \geq 300$ mb

QC T(p) = 2 otherwise (QC never = 1 over ocean)

Version 4

QC T(p) = 0 within three distinct pressure ranges if ad-hoc individual tests are passed

QC T(p) = 1 for $p \geq 500$ mb if mid-tropospheric temperature test is passed - both land and ocean

QC T(p) = 2 otherwise

Land skin temperature, emissivity - same for Version 5 and Version 4

QC = 1 if QC surf air = 1

QC = 2 otherwise

Sea surface temperature - same for Version 5 and Version 4

QC = 0 if tight test is passed

QC = 1 if standard test is passed

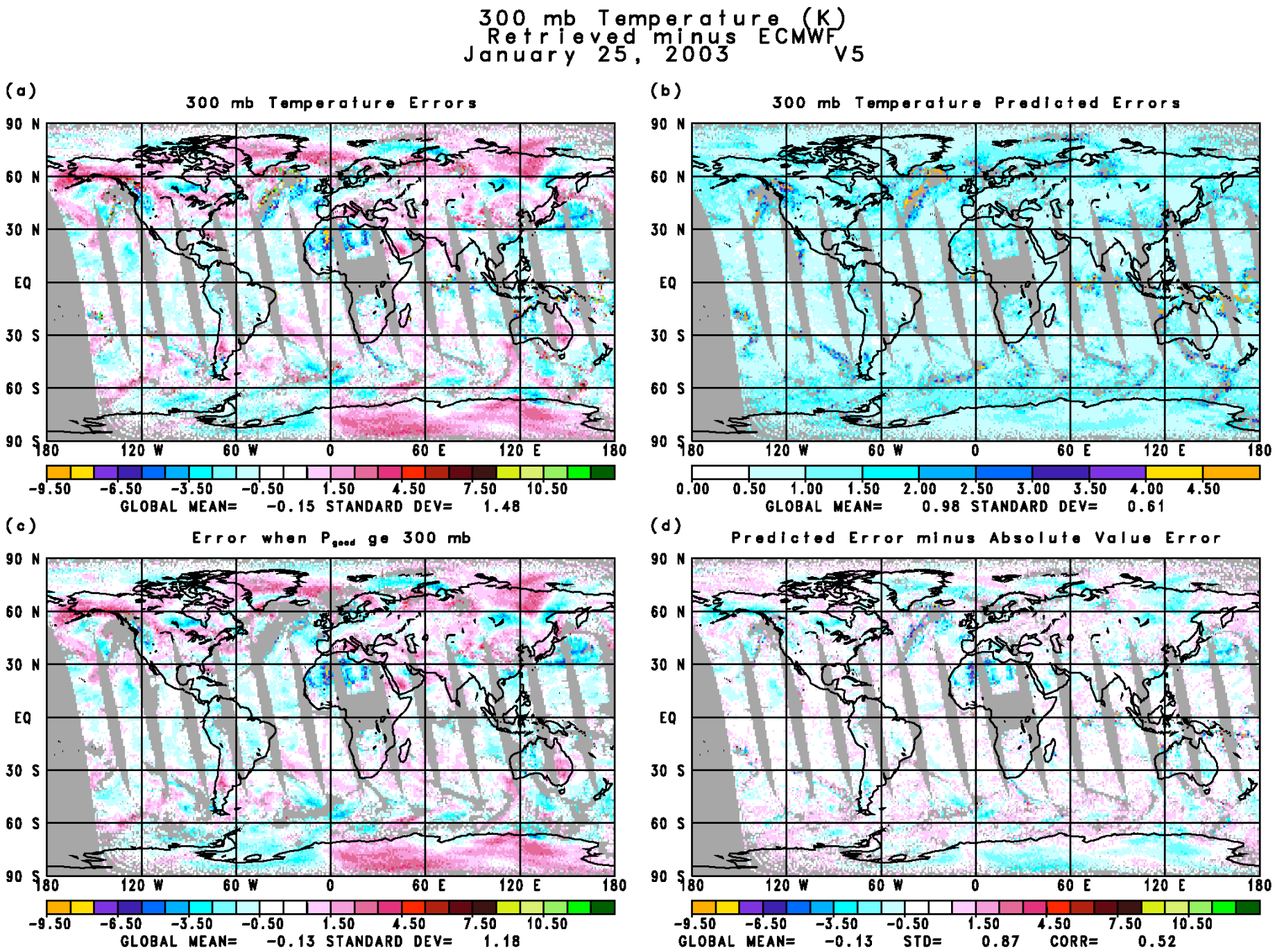
Constituent test

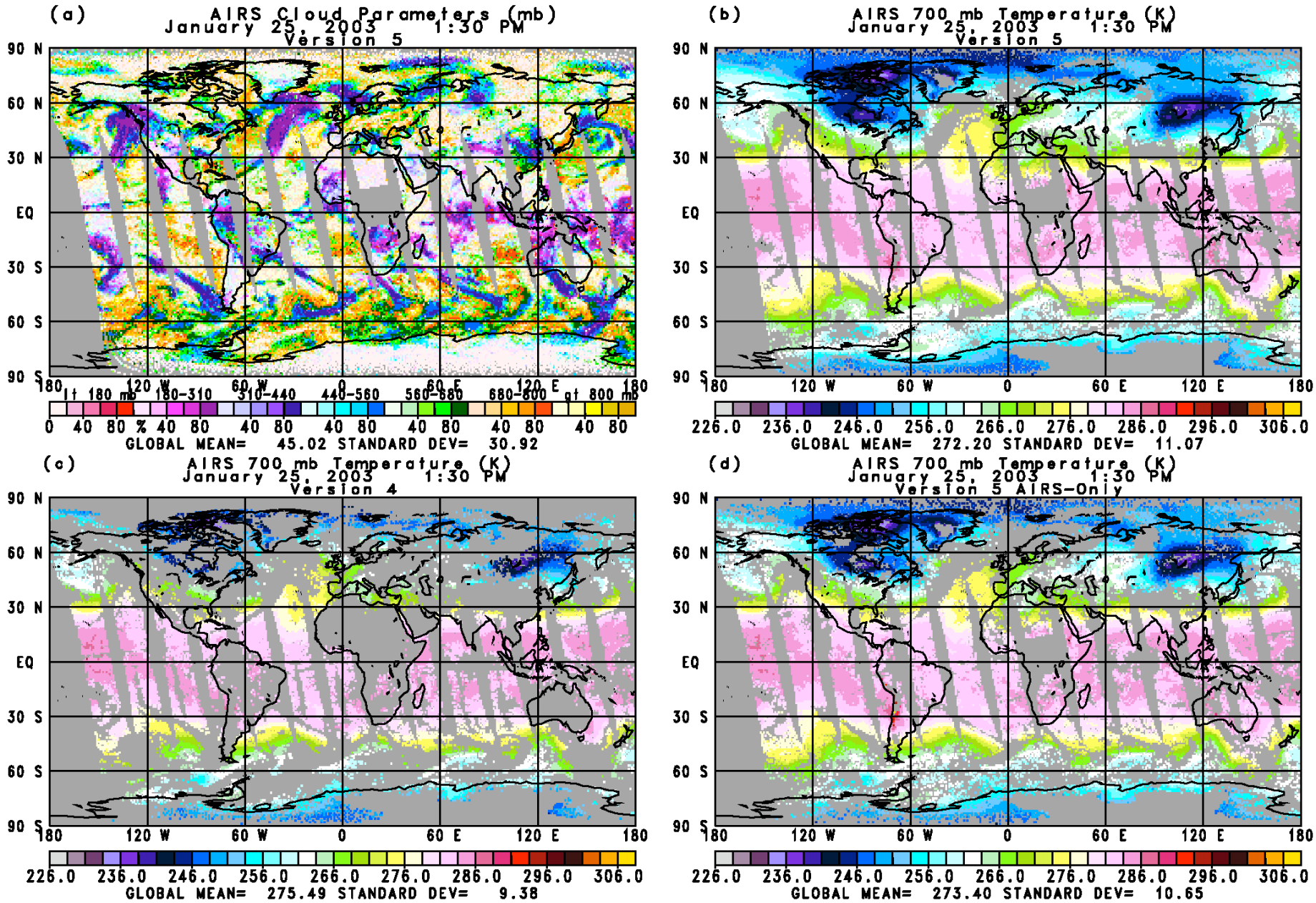
Passed if $\delta W_{tot} / W_{tot} \leq 0.35$ in Version 5

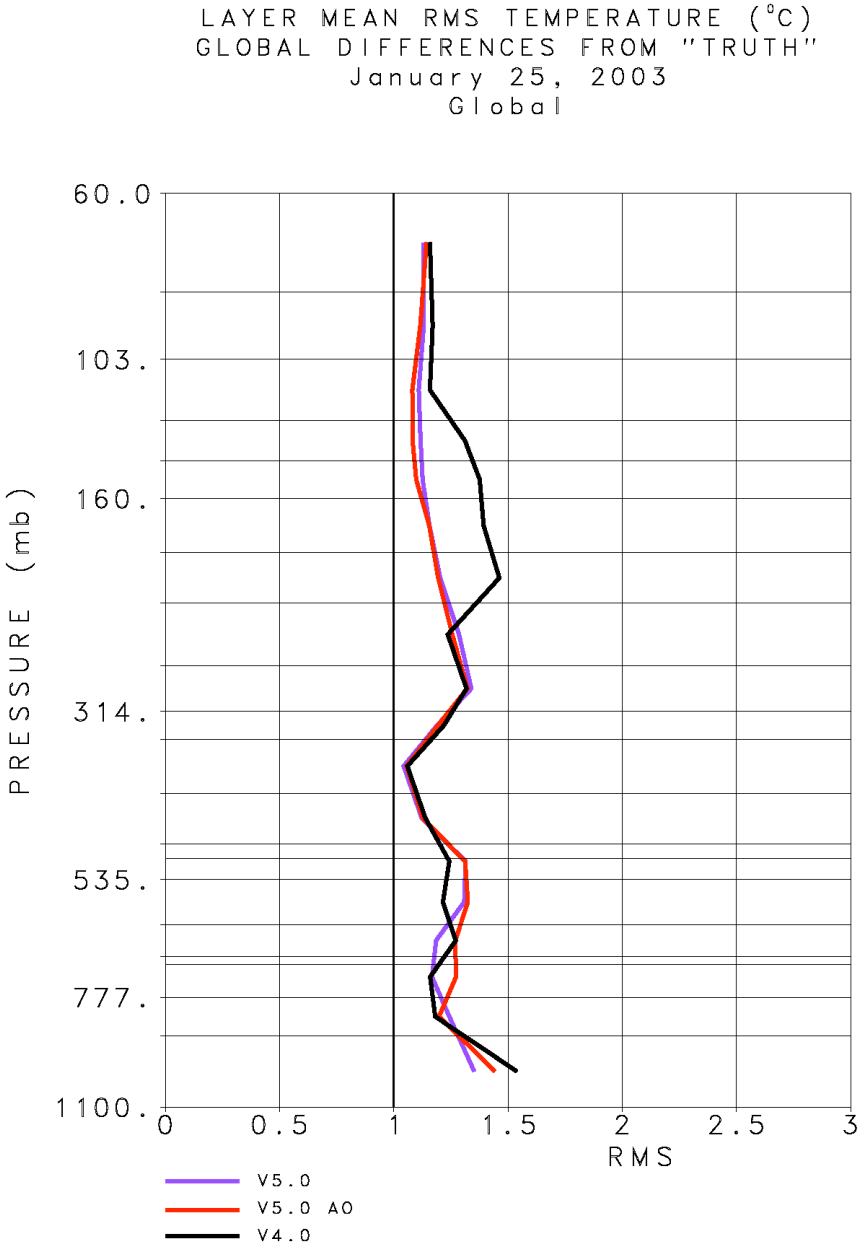
Passed with ad-hoc test in Version 4

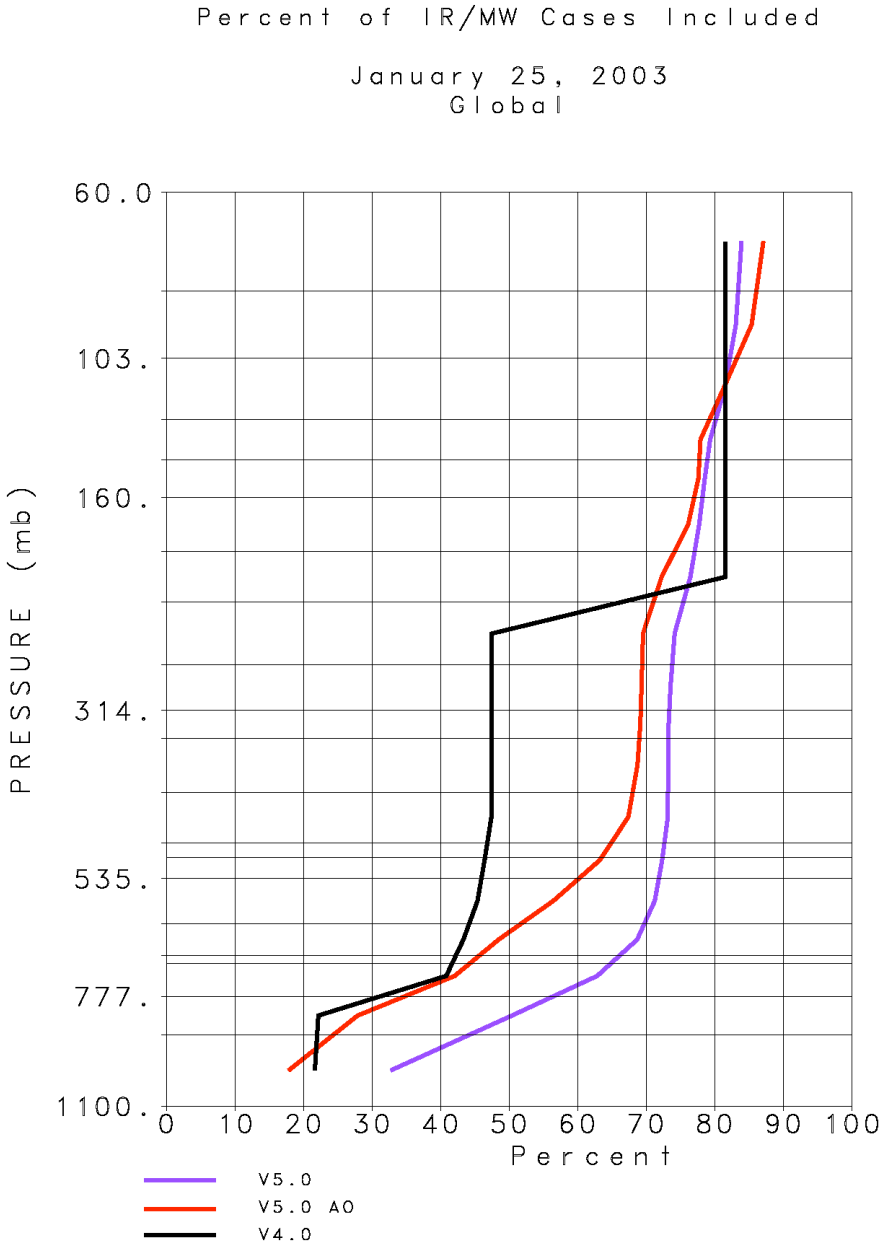
QC q(p) = 2 if constituent test fails, QC q(p) = 0 or 1 if constituent test is passed

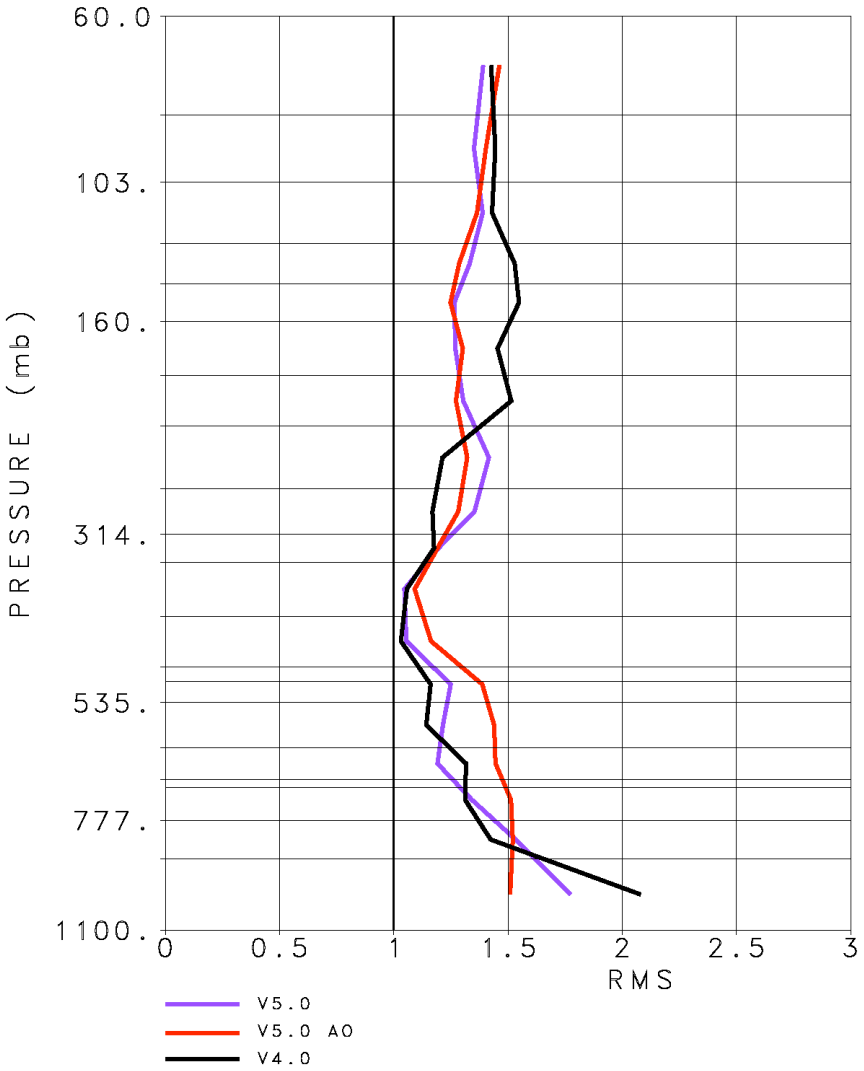
QC q(p) = 0 only if QC T(p) = 0

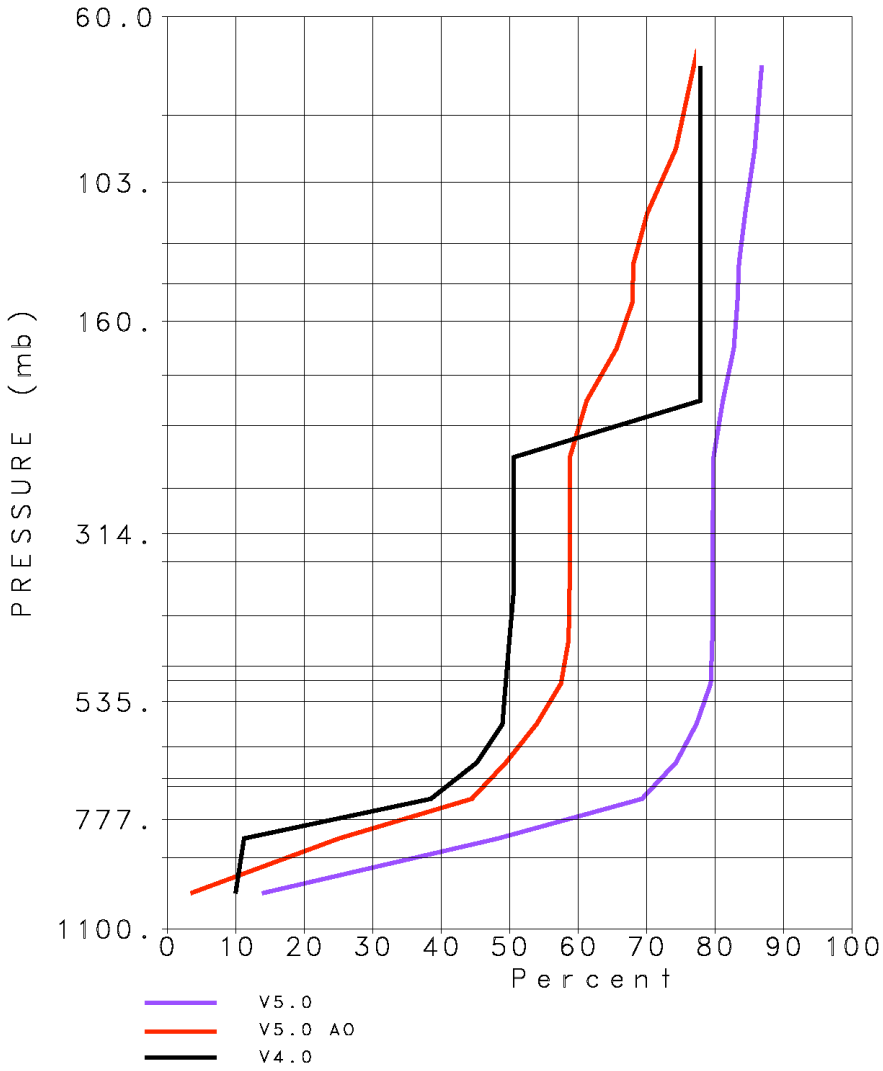

300 mb Temperature (K)
Retrieved minus ECMWF
January 25, 2003 V5
(a)
300 mb Temperature Errors
90 N
60 N
30 N
EQ
30 S
60 S
90 S
180 120 W 60 W 0 60 E 120 E 180
-9.50 -6.50 -3.50 -0.50 1.50 4.50 7.50 10.50
GLOBAL MEAN= -0.15 STANDARD DEV= 1.48
(b)
300 mb Temperature Predicted Errors
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50
GLOBAL MEAN= 0.98 STANDARD DEV= 0.61
(c)
Error when P_{good} ge 300 mb
GLOBAL MEAN= -0.13 STANDARD DEV= 1.18
(d)
Predicted Error minus Absolute Value Error
GLOBAL MEAN= -0.13 STD= 0.87 CORR= 0.52

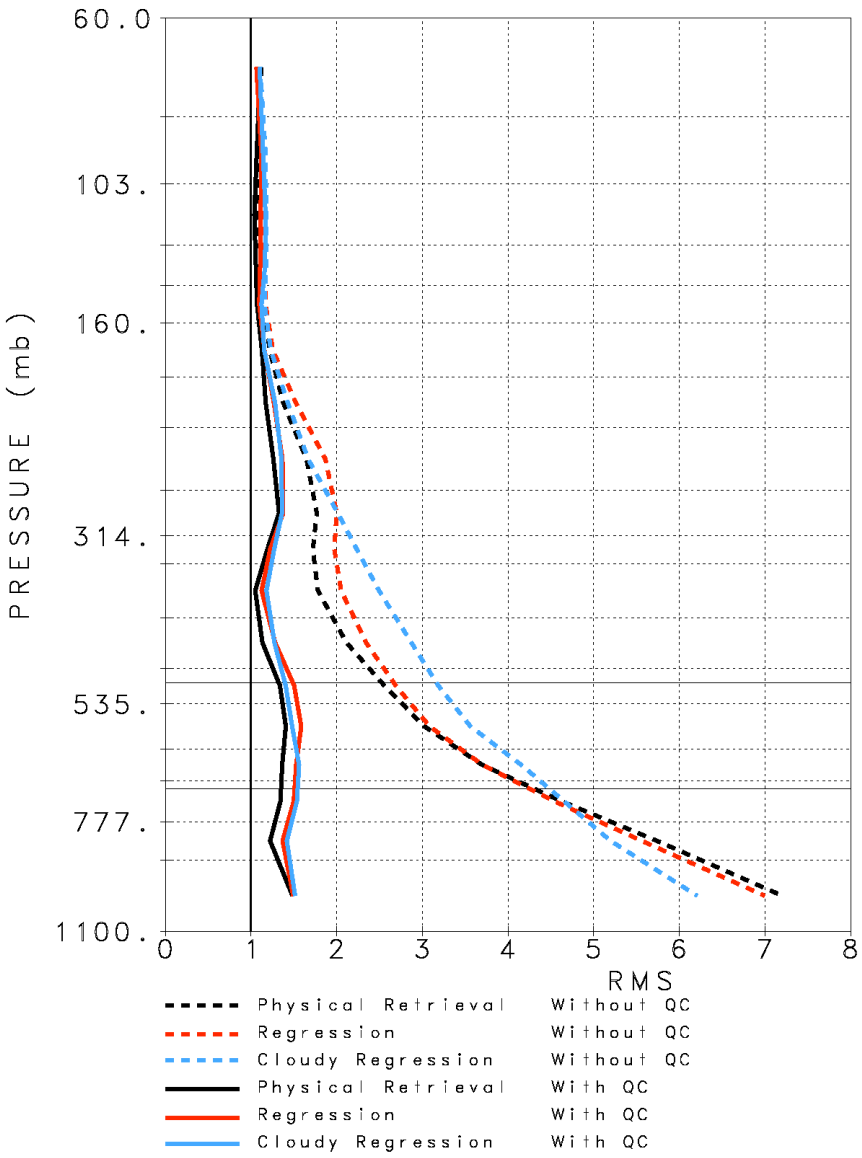

(a)
AIRS Cloud Parameters (mb)
January 25, 2003 1:30 PM
Version 5
90 N
60 N
30 N
EQ
30 S
60 S
90 S
180 120 W 60 W 0 60 E 120 E 180
lt 180 mb 180-310 310-440 440-560 560-680 680-800 gt 800 mb
0 40 80 % 40 80 40 80 40 80 40 80 40 80 40 80
GLOBAL MEAN= 45.02 STANDARD DEV= 30.92
(b)
AIRS 700 mb Temperature (K)
January 25, 2003 1:30 PM
Version 5
226.0 236.0 246.0 256.0 266.0 276.0 286.0 296.0 306.0
GLOBAL MEAN= 272.20 STANDARD DEV= 11.07
(c)
AIRS 700 mb Temperature (K)
January 25, 2003 1:30 PM
Version 4
GLOBAL MEAN= 275.49 STANDARD DEV= 9.38
(d)
AIRS 700 mb Temperature (K)
January 25, 2003 1:30 PM
Version 5 AIRS-Only
GLOBAL MEAN= 273.40 STANDARD DEV= 10.65

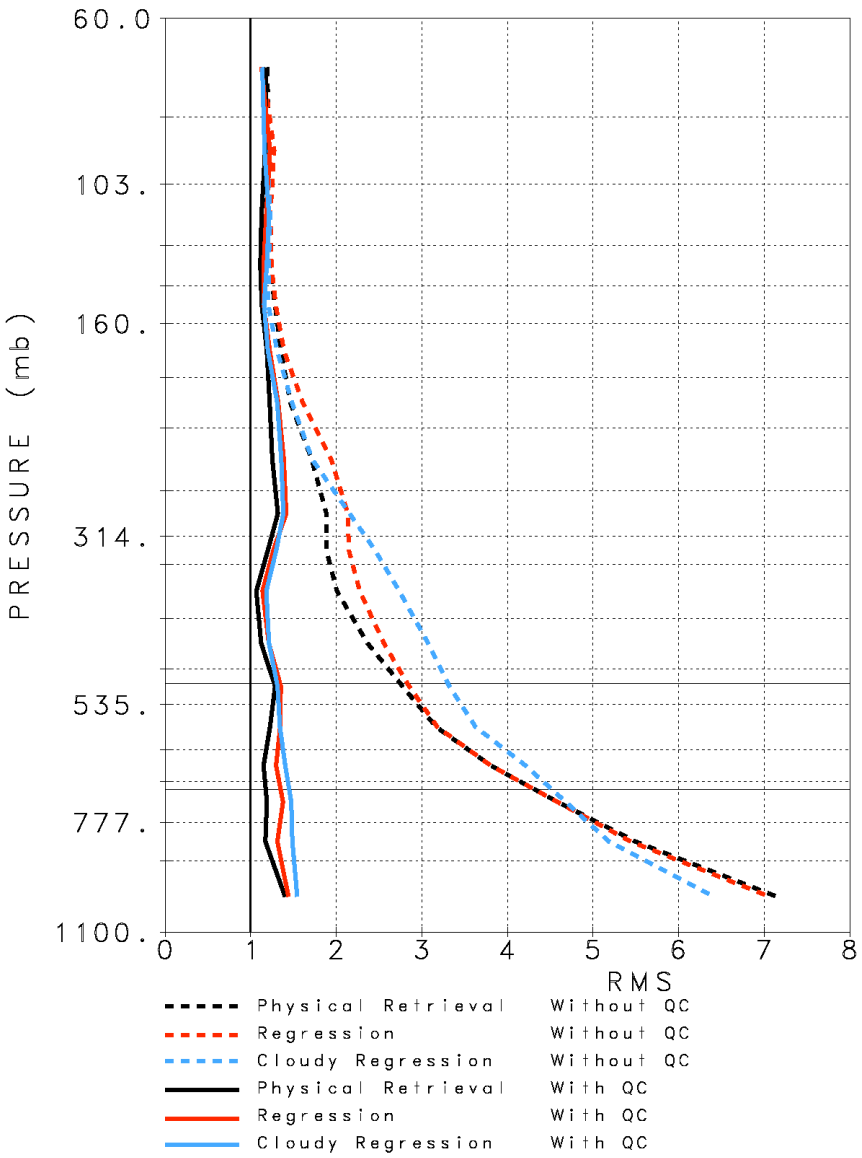

LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM "TRUTH"
January 25, 2003
Global
PRESSURE (mb)
60.0
103.
160.
314.
535.
777.
1100.
0
0.5
1
1.5
2
2.5
3
RMS
V5.0
V5.0 AO
V4.0


Percent of IR/MW Cases Included
January 25, 2003
Global
PRESSURE (mb)
60.0
103.
160.
314.
535.
777.
1100.
0
10
20
30
40
50
60
70
80
90
100
Percent
V5.0
V5.0 AO
V4.0


LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM "TRUTH"
January 25, 2003
50N to 50S Non-Ocean
PRESSURE (mb)
60.0
103.
160.
314.
535.
777.
1100.
0
0.5
1
1.5
2
2.5
3
RMS
V5.0
V5.0 AO
V4.0


Percent of IR/MW Cases Included
January 25, 2003
50N to 50S Non-Ocean
PRESSURE (mb)
60.0
103.
160.
314.
535.
777.
1100.
0
10
20
30
40
50
60
70
80
90
100
Percent
V5.0
V5.0 AO
V4.0


LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM "TRUTH"
Version 5 AIRS Only
Global
January 25, 2003 Nighttime
PRESSURE (mb)
60.0
103.
160.
314.
535.
777.
1100.
0
1
2
3
4
5
6
7
8
RMS
Physical Retrieval Without QC
Regression Without QC
Cloudy Regression Without QC
Physical Retrieval With QC
Regression With QC
Cloudy Regression With QC


LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM "TRUTH"
Version 5 AIRS Only
Global
January 25, 2003 Daytime
PRESSURE (mb)
60.0
103.
160.
314.
535.
777.
1100.
0
1
2
3
4
5
6
7
8
RMS
Physical Retrieval Without QC
Regression Without QC
Cloudy Regression Without QC
Physical Retrieval With QC
Regression With QC
Cloudy Regression With QC

FORECAST IMPACT TEST

Experiments run with GSFC GOES-5 data assimilation system

Forecasts run at 1° x 1° resolution

Analysis using NCEP GSI analysis at 1° x 1° resolution

Data period covers January 1, 2003 - January 31, 2003

Control uses all data NCEP used operationally at that time

Assimilates all satellite data but AIRS, including Aqua AMSU radiances

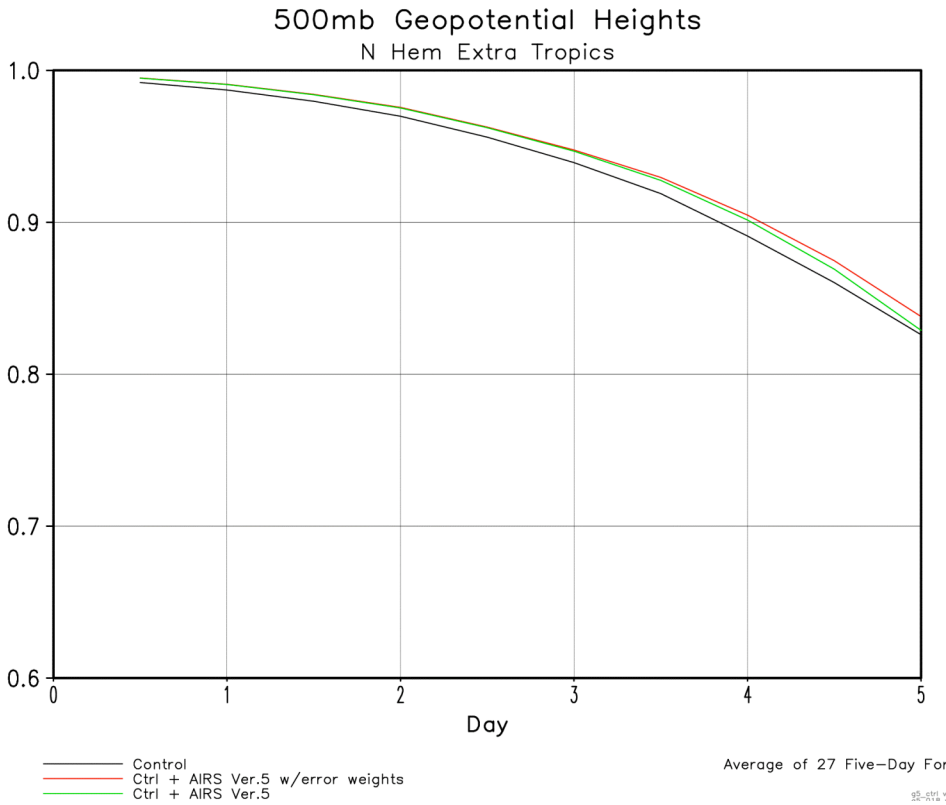
Control + AIRS V5 adds V5.0 global quality controlled T(p) retrievals

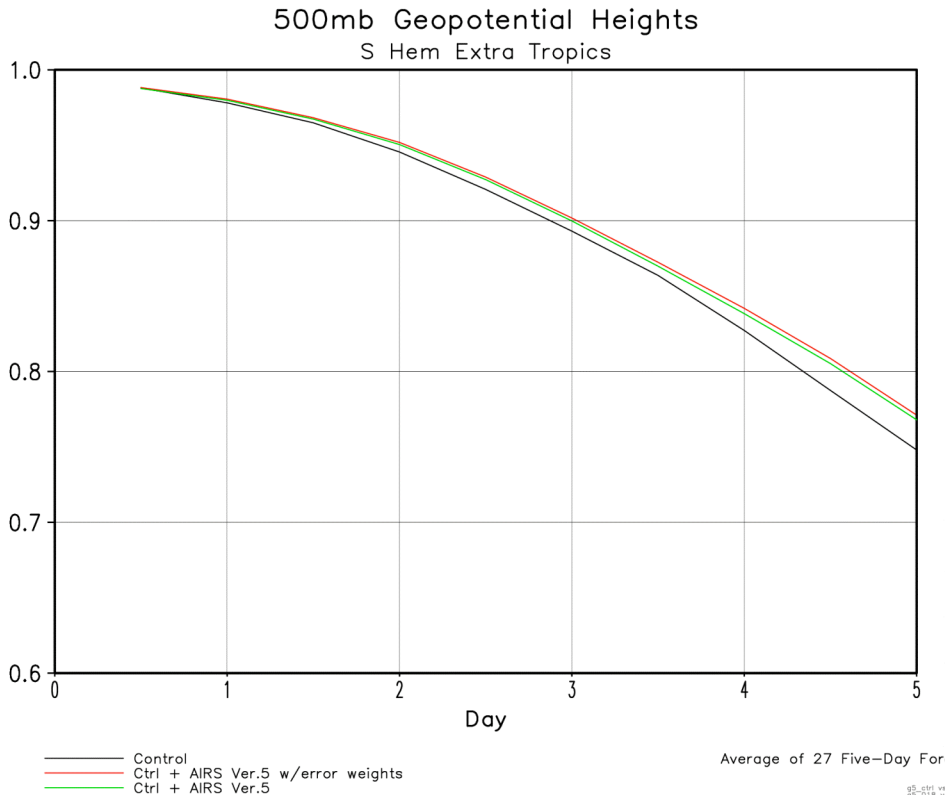
All AIRS T(p) data treated as radiosonde reports -1K uncertainty

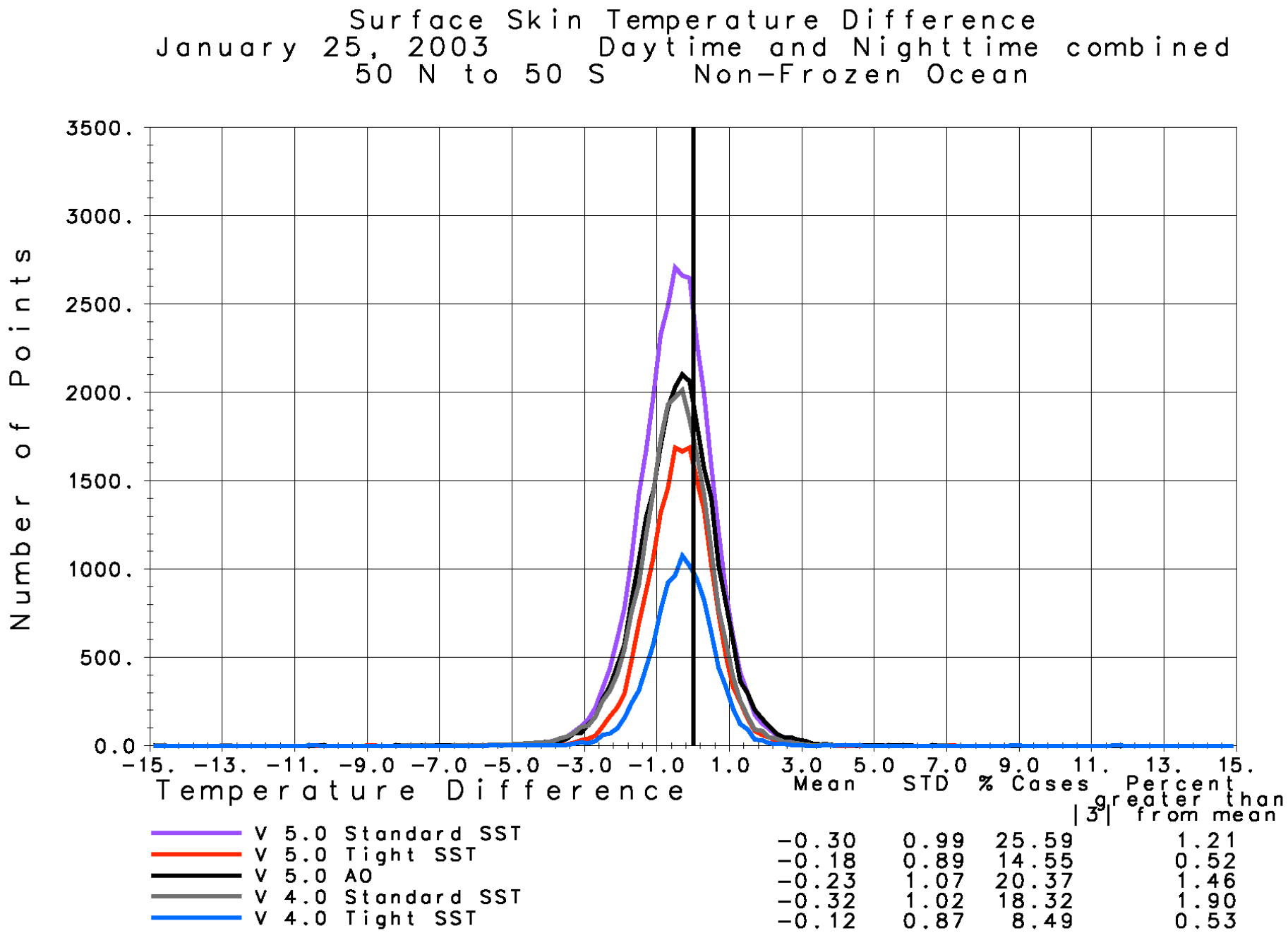
Control + AIRS V5 with error weights adds V5.0 global quality controlled T(p) retrievals

All AIRS T(p) data treated as radiosonde reports with reported uncertainty $\delta T(p)$

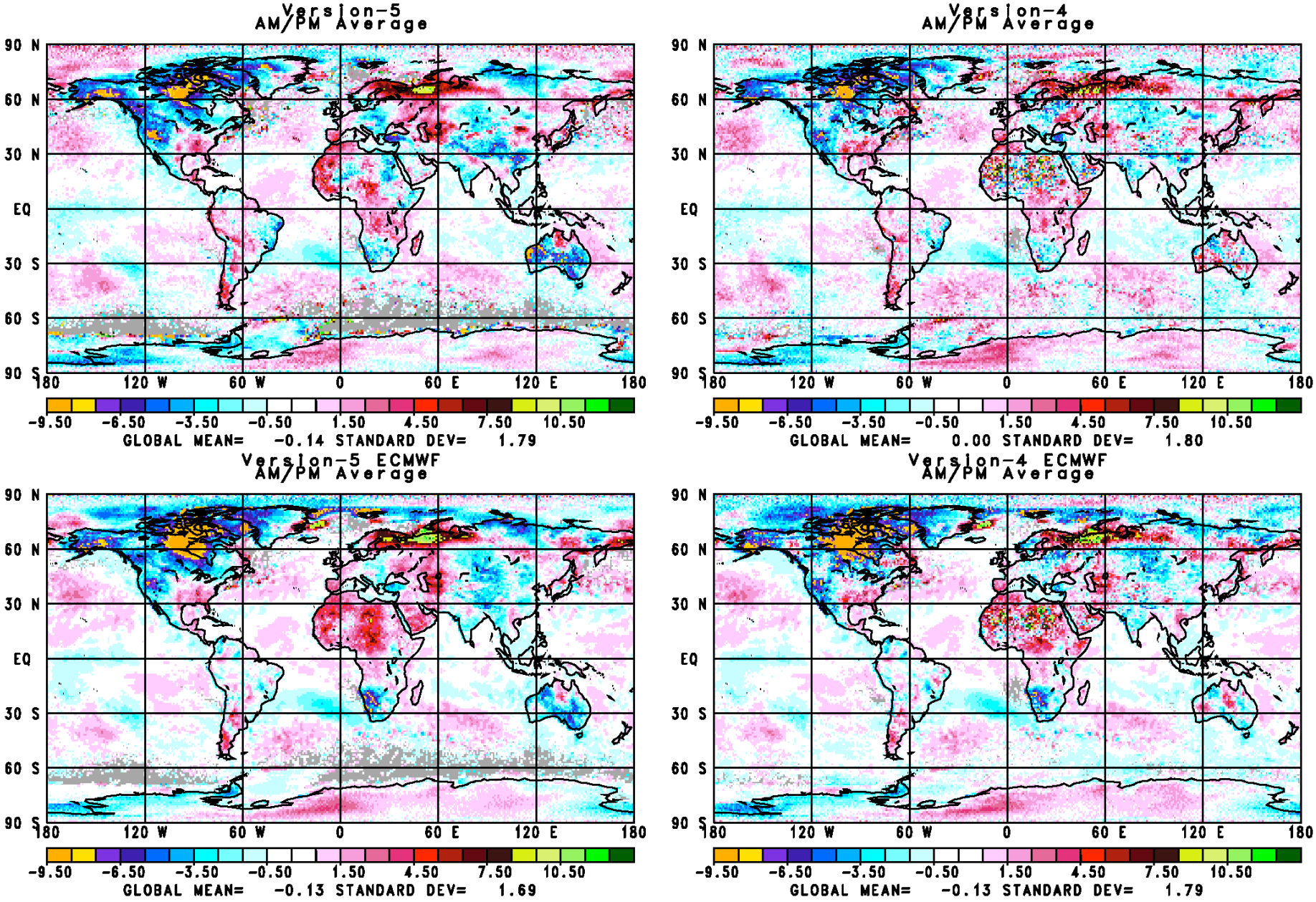
27 independent forecasts run from each analysis


500mb Geopotential Heights
N Hem Extra Tropics
1.0
0.9
0.8
0.7
0.6
0
1
2
3
4
5
Day
Control
Ctrl + AIRS Ver.5 w/error weights
Ctrl + AIRS Ver.5
Average of 27 Five-Day For

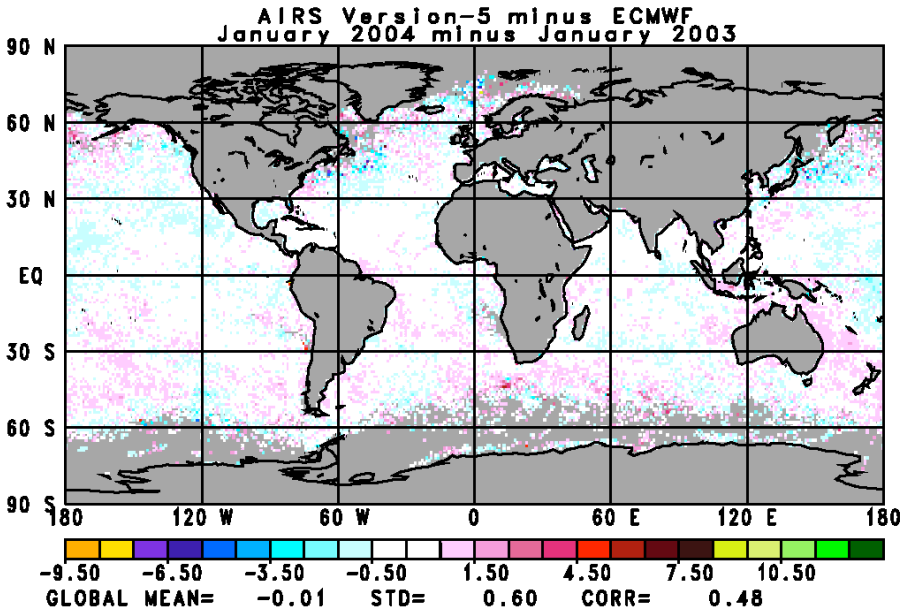

500mb Geopotential Heights
S Hem Extra Tropics
1.0
0.9
0.8
0.7
0.6
0
1
2
3
4
5
Day
Control
Ctrl + AIRS Ver.5 w/error weights
Ctrl + AIRS Ver.5
Average of 27 Five-Day For

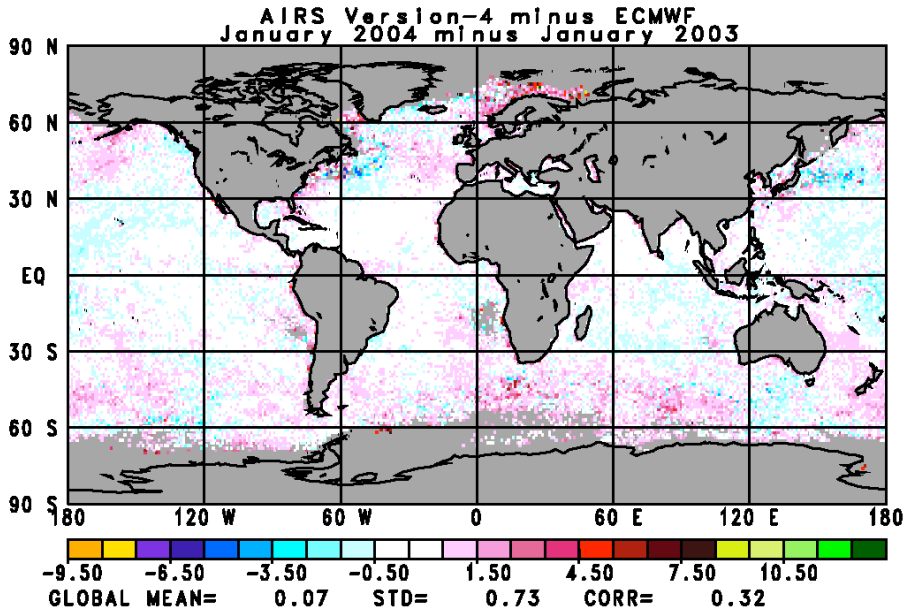

Surface Skin Temperature Difference
January 25, 2003 Daytime and Nighttime combined
50 N to 50 S Non-Frozen Ocean
Number of Points
3500.
3000.
2500.
2000.
1500.
1000.
500.
0.0
-15. -13. -11. -9.0 -7.0 -5.0 -3.0 -1.0 1.0 3.0 5.0 7.0 9.0 11. 13. 15.
Temperature Difference
V 5.0 Standard SST
V 5.0 Tight SST
V 5.0 AO
V 4.0 Standard SST
V 4.0 Tight SST
Mean STD % Cases Percent greater than |3| from mean
-0.30 0.99 25.59 1.21
-0.18 0.89 14.55 0.52
-0.23 1.07 20.37 1.46
-0.32 1.02 18.32 1.90
-0.12 0.87 8.49 0.53

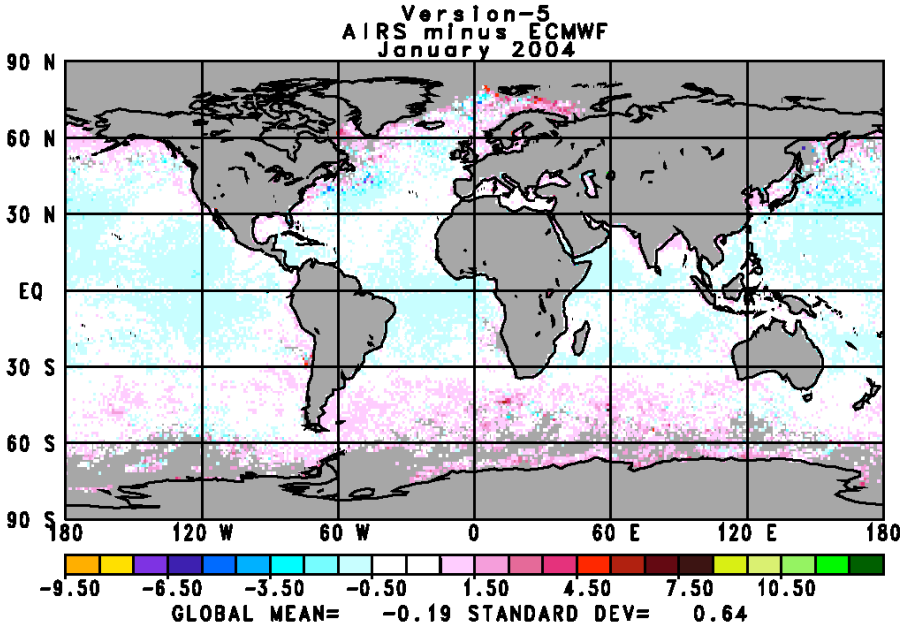
AIRS Surface Skin Temperature (K)
January 2004 minus January 2003
QC = 0 and 1

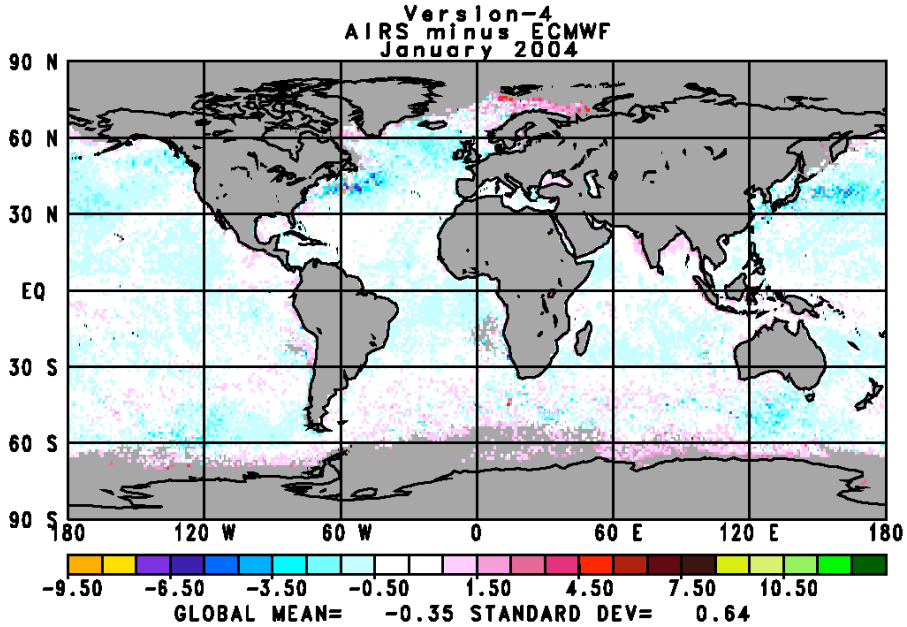


Sea Surface Temperature (K)
QC = 0 and 1

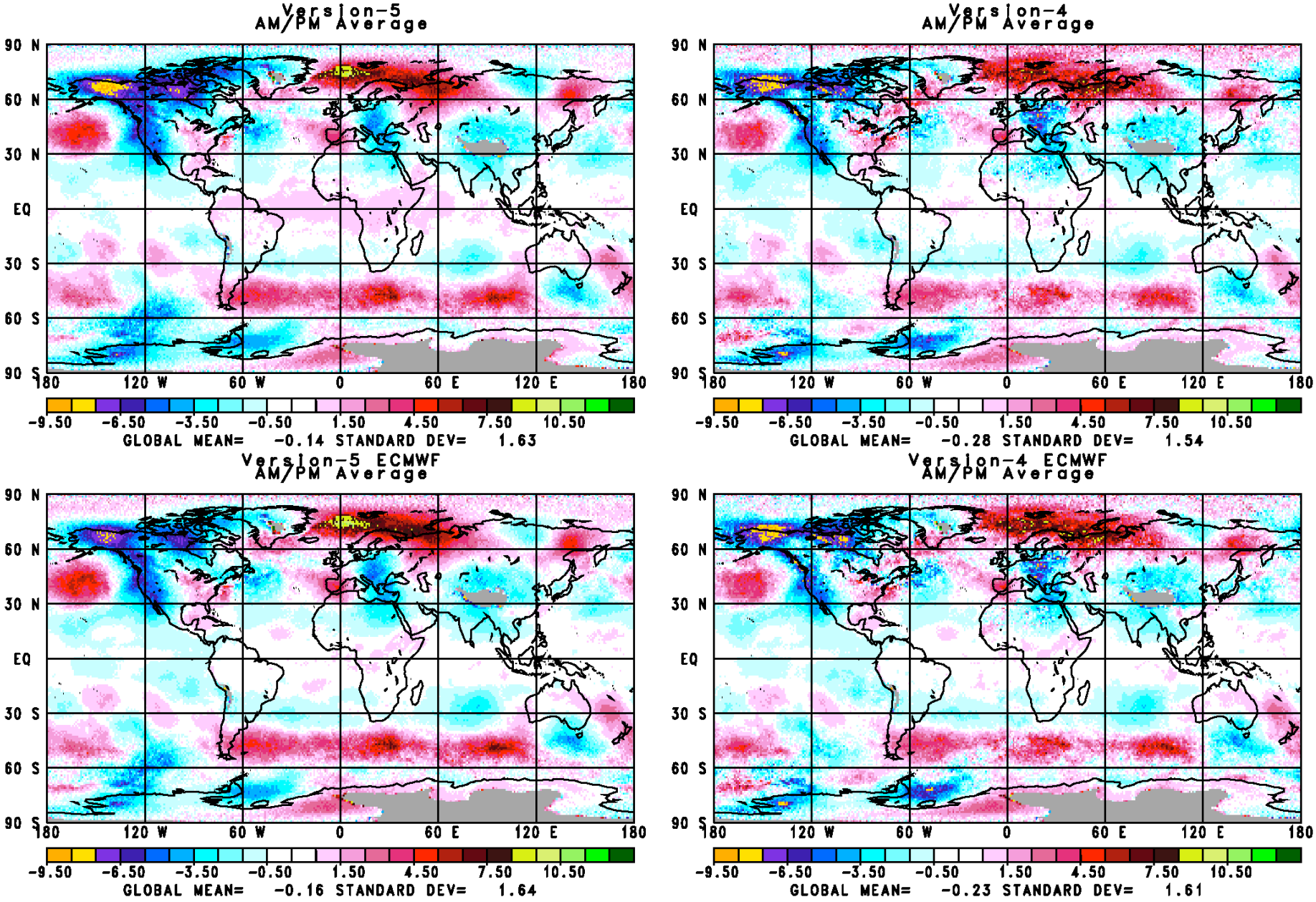




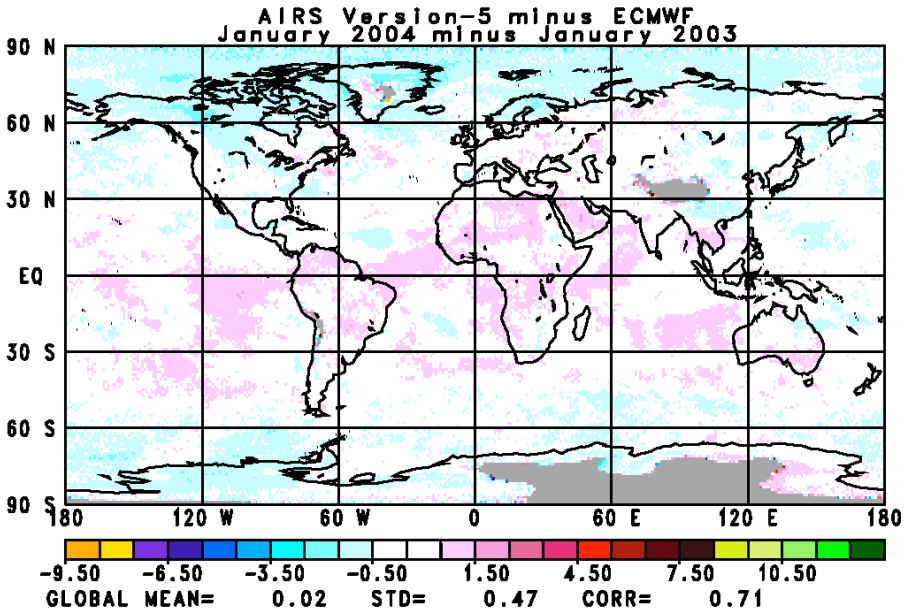


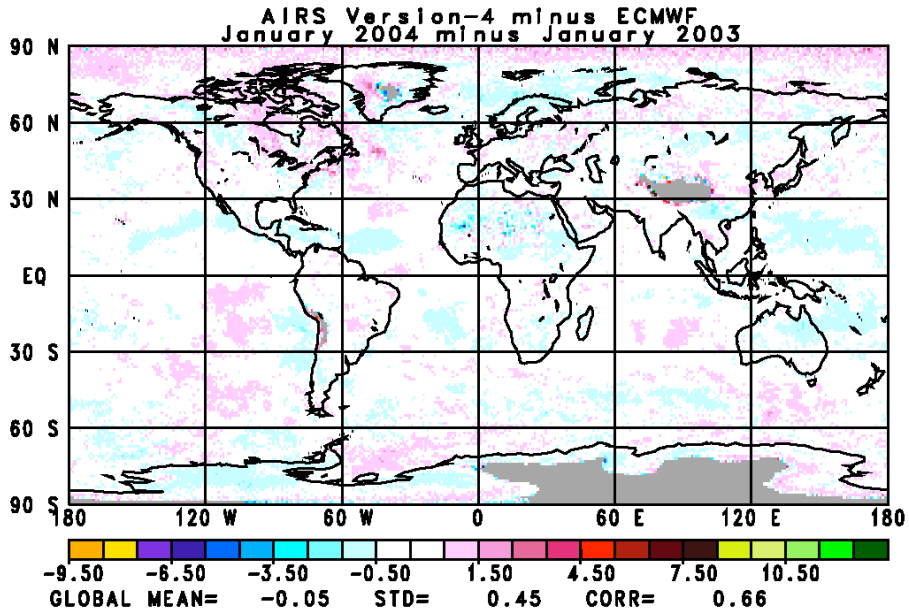


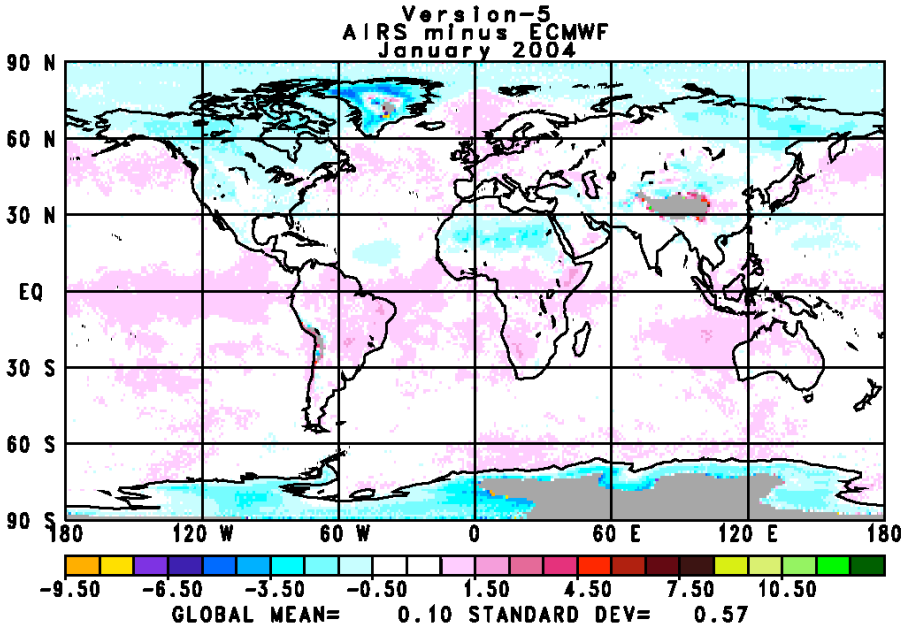
AIRS 700 mb Temperature (K)
January 2004 minus January 2003
QC = 0 and 1

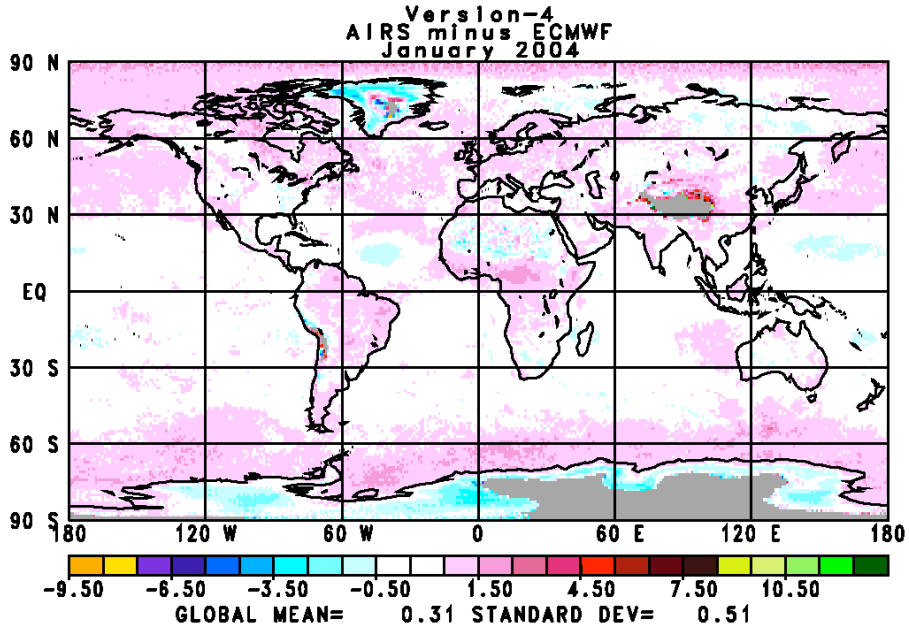


# 700 mb Temperature (K)
QC = 0 and 1

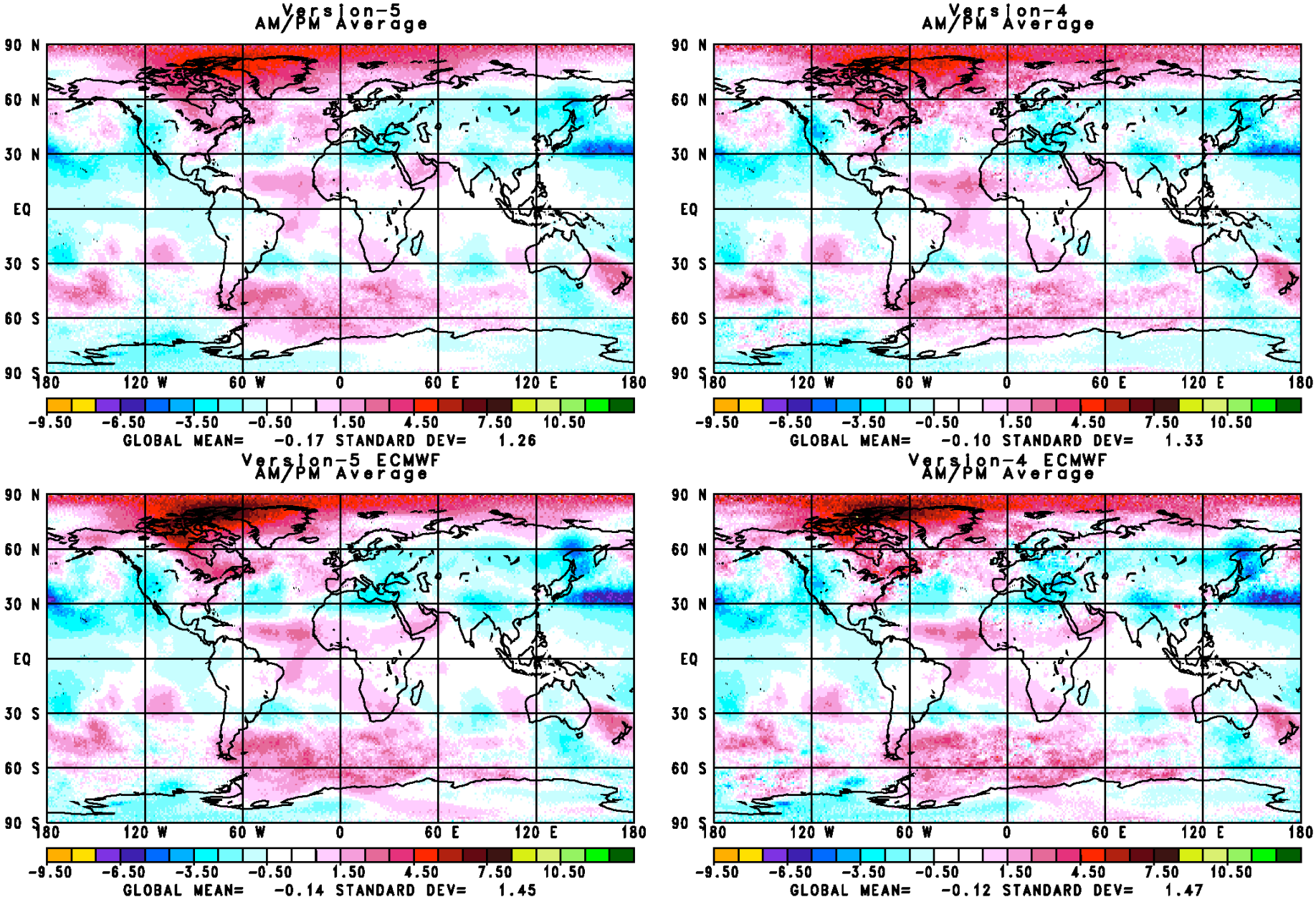




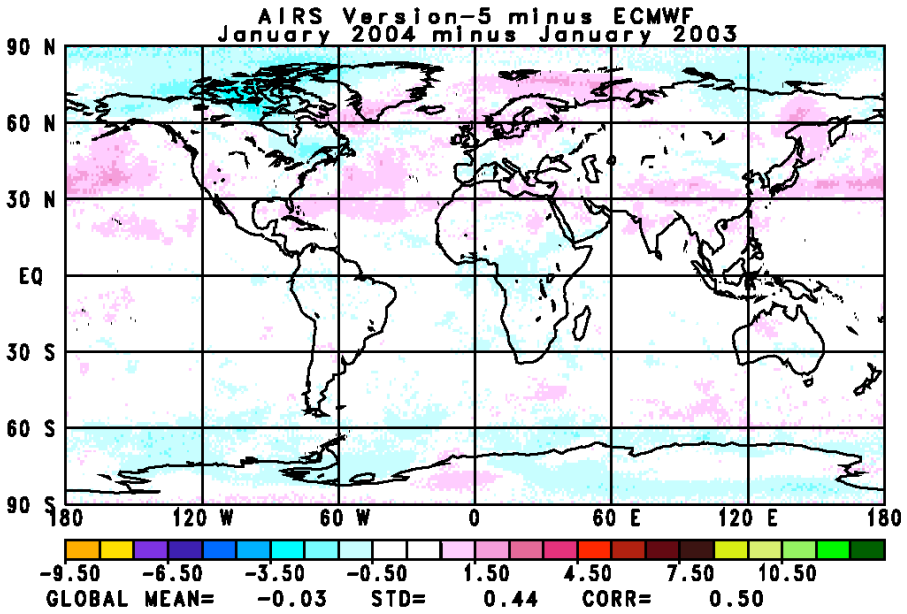


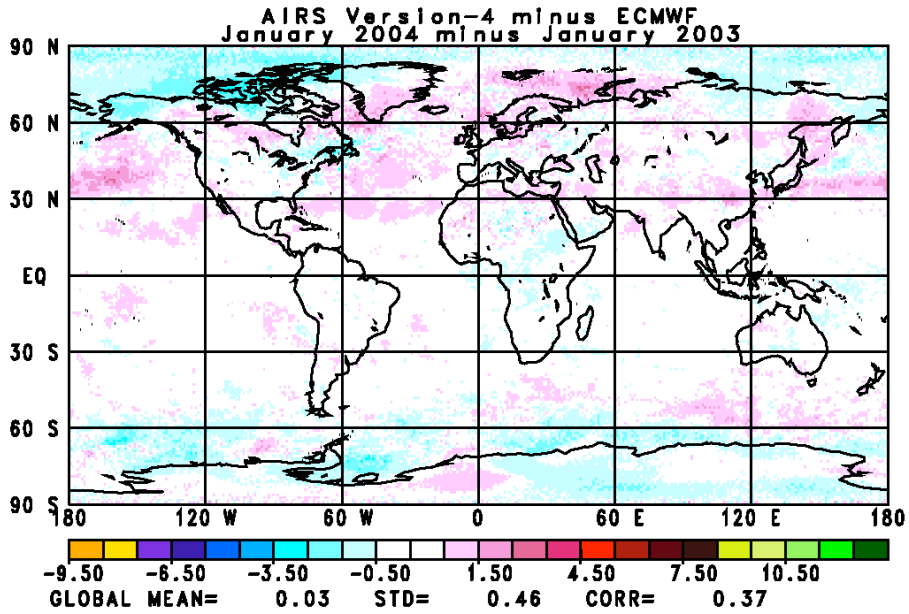


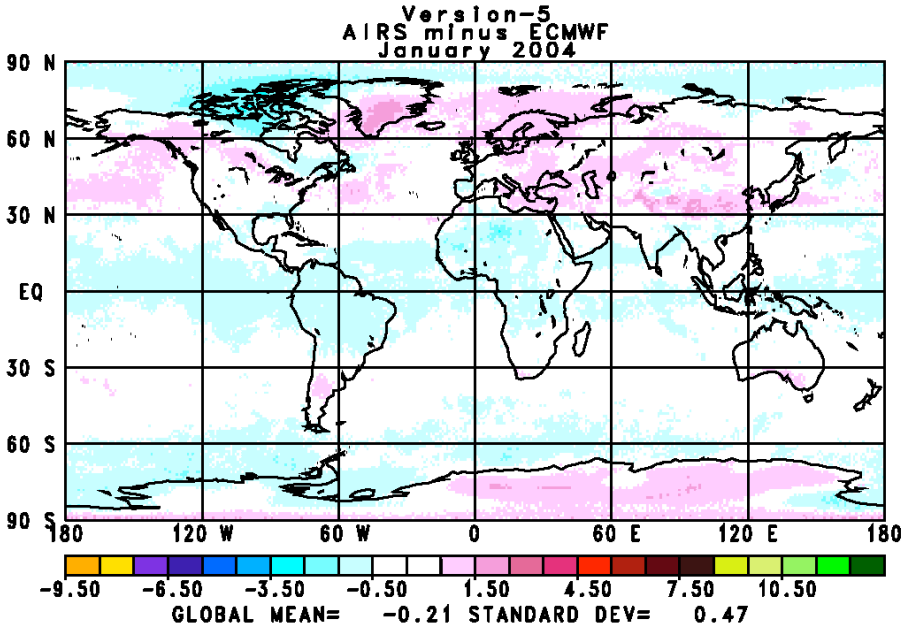
AIRS 300 mb Temperature (K)
January 2004 minus January 2003
QC = 0 and 1

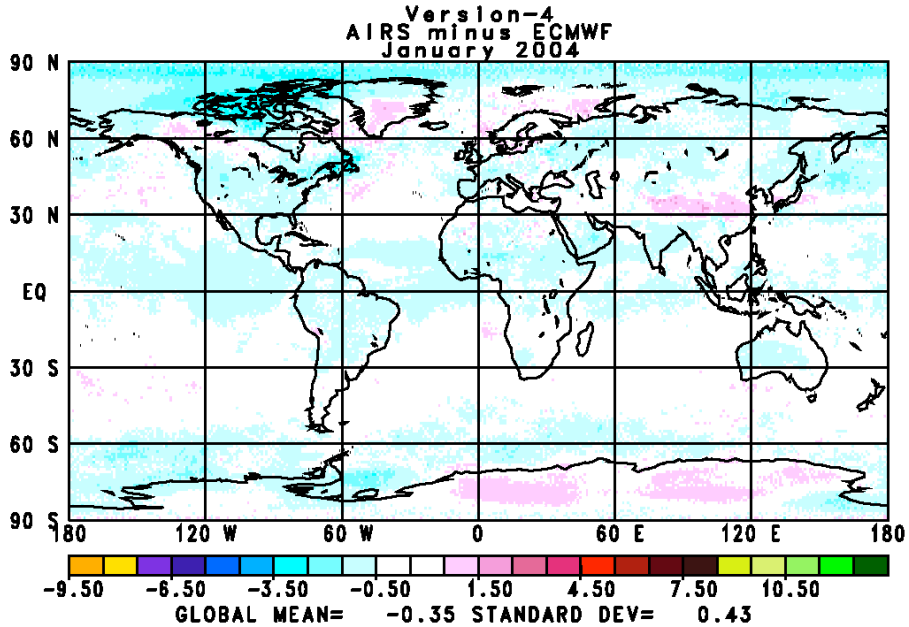


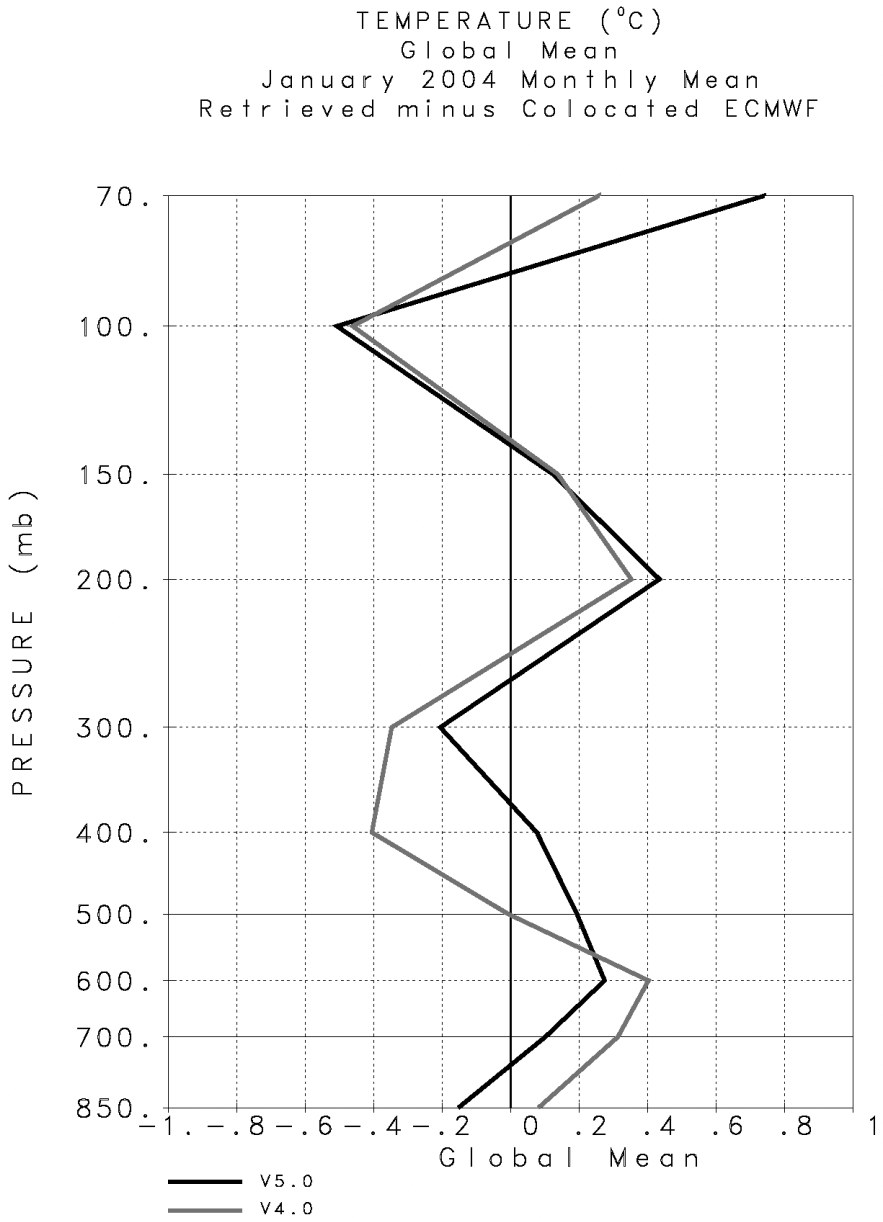
# 300 mb Temperature (K)
QC = 0 and 1

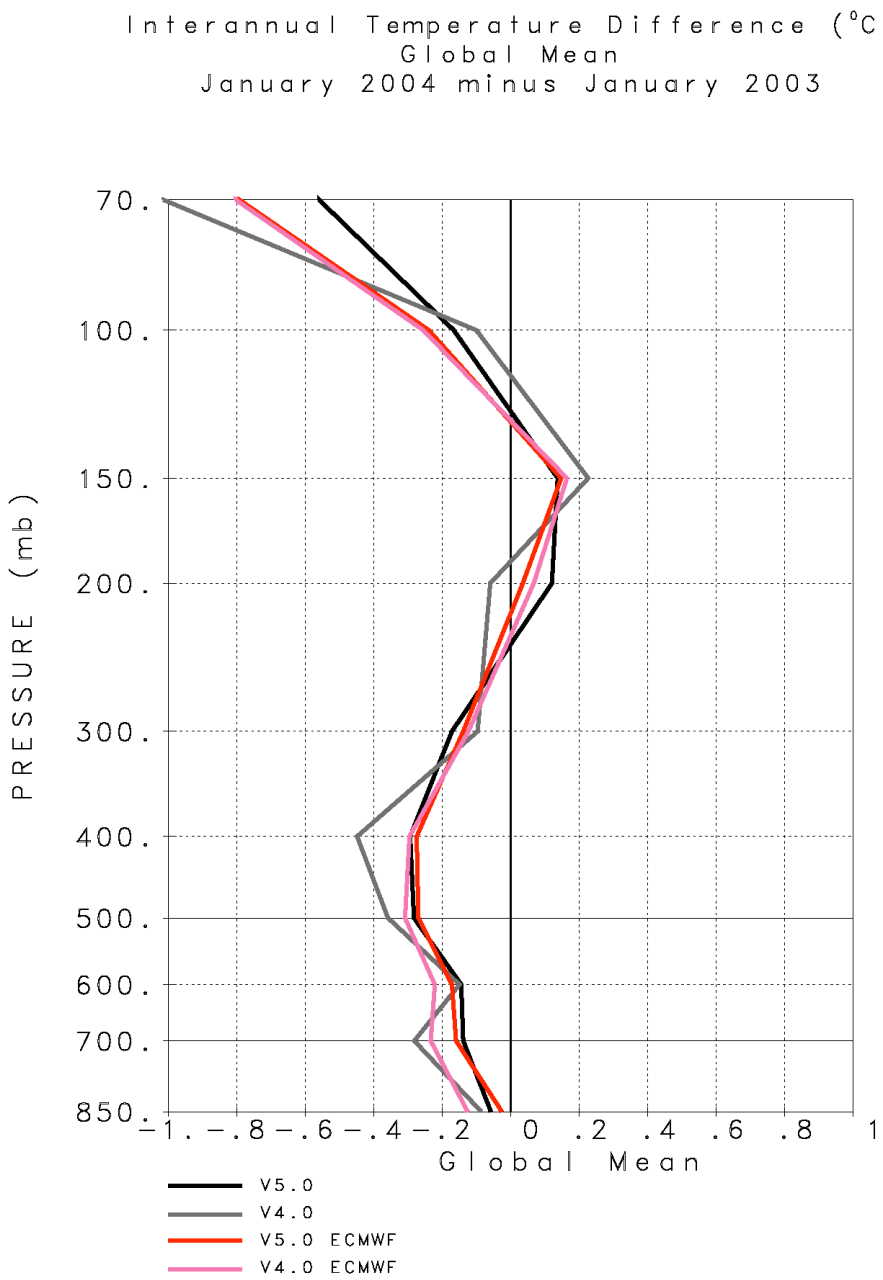




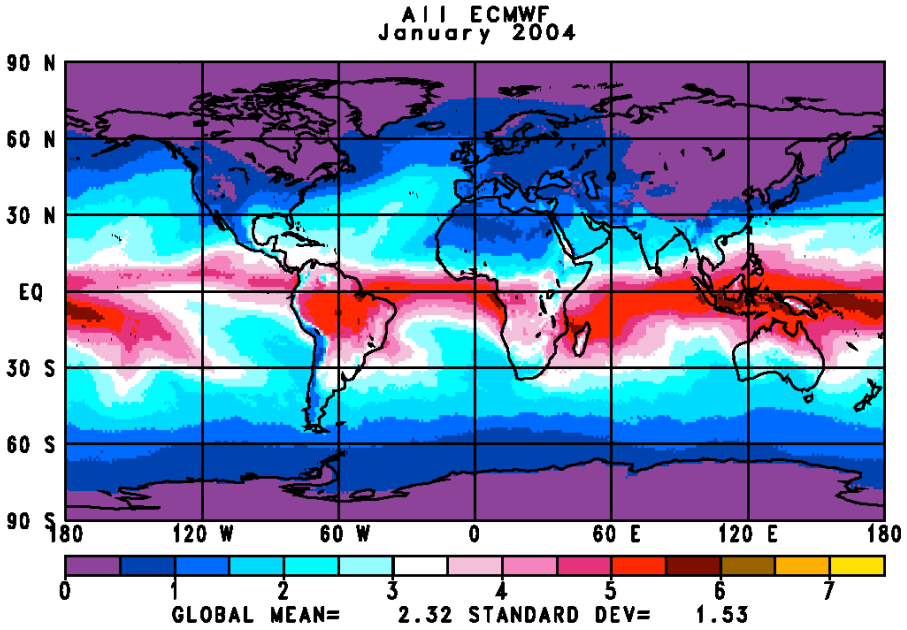


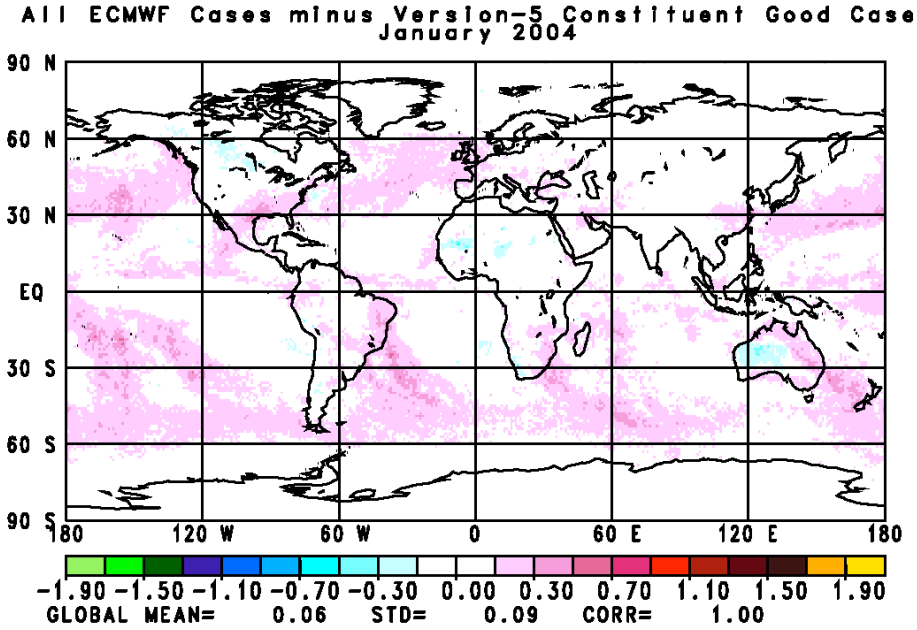


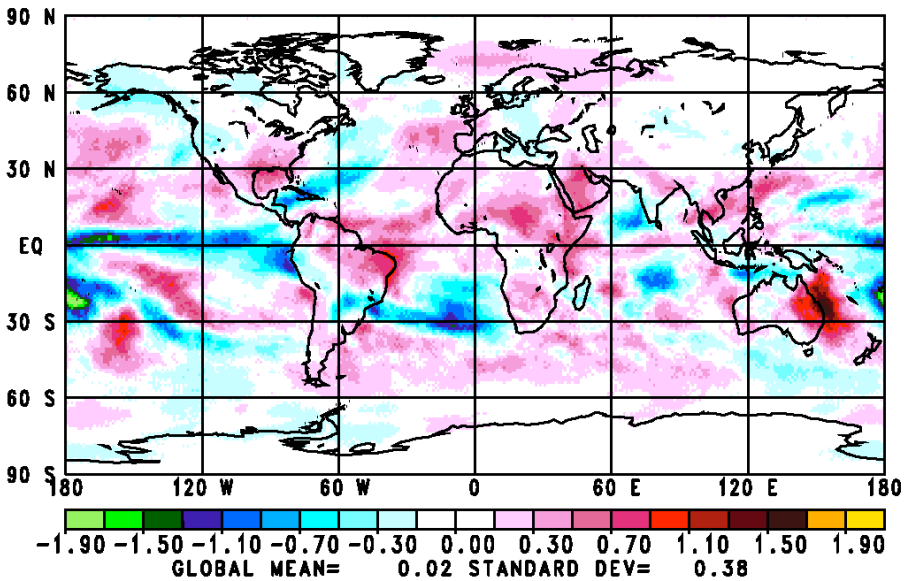

TEMPERATURE (°C)
Global Mean
January 2004 Monthly Mean
Retrieved minus Colocated ECMWF
PRESSURE (mb)
70.
100.
150.
200.
300.
400.
500.
600.
700.
850.
−1. −.8 −.6 −.4 −.2 0 .2 .4 .6 .8 1
Global Mean
V5.0
V4.0

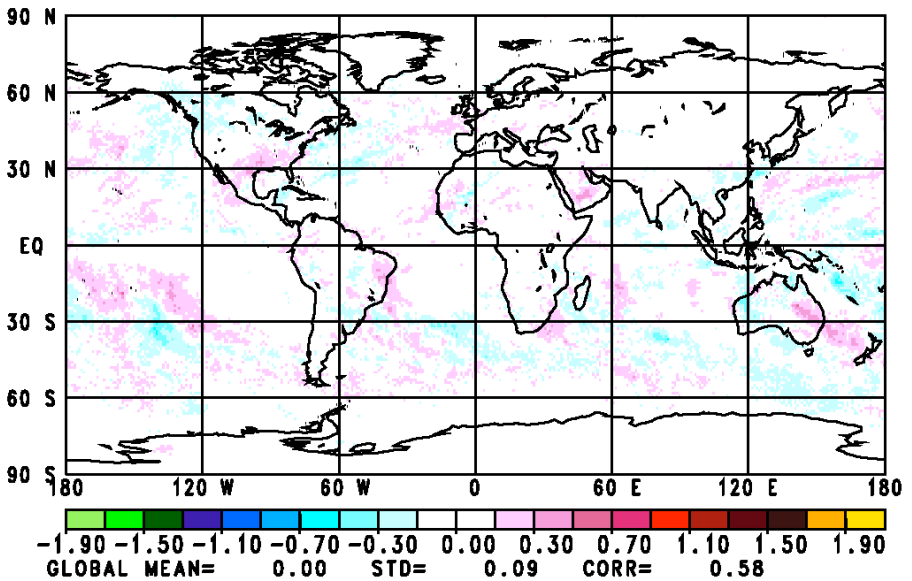

Interannual Temperature Difference (°C)
Global Mean
January 2004 minus January 2003
PRESSURE (mb)
70.
100.
150.
200.
300.
400.
500.
600.
700.
850.
−1. −.8 −.6 −.4 −.2 0 .2 .4 .6 .8 1
Global Mean
V5.0
V4.0
V5.0 ECMWF
V4.0 ECMWF

Total Precipitable Water (cm)
ECMWF

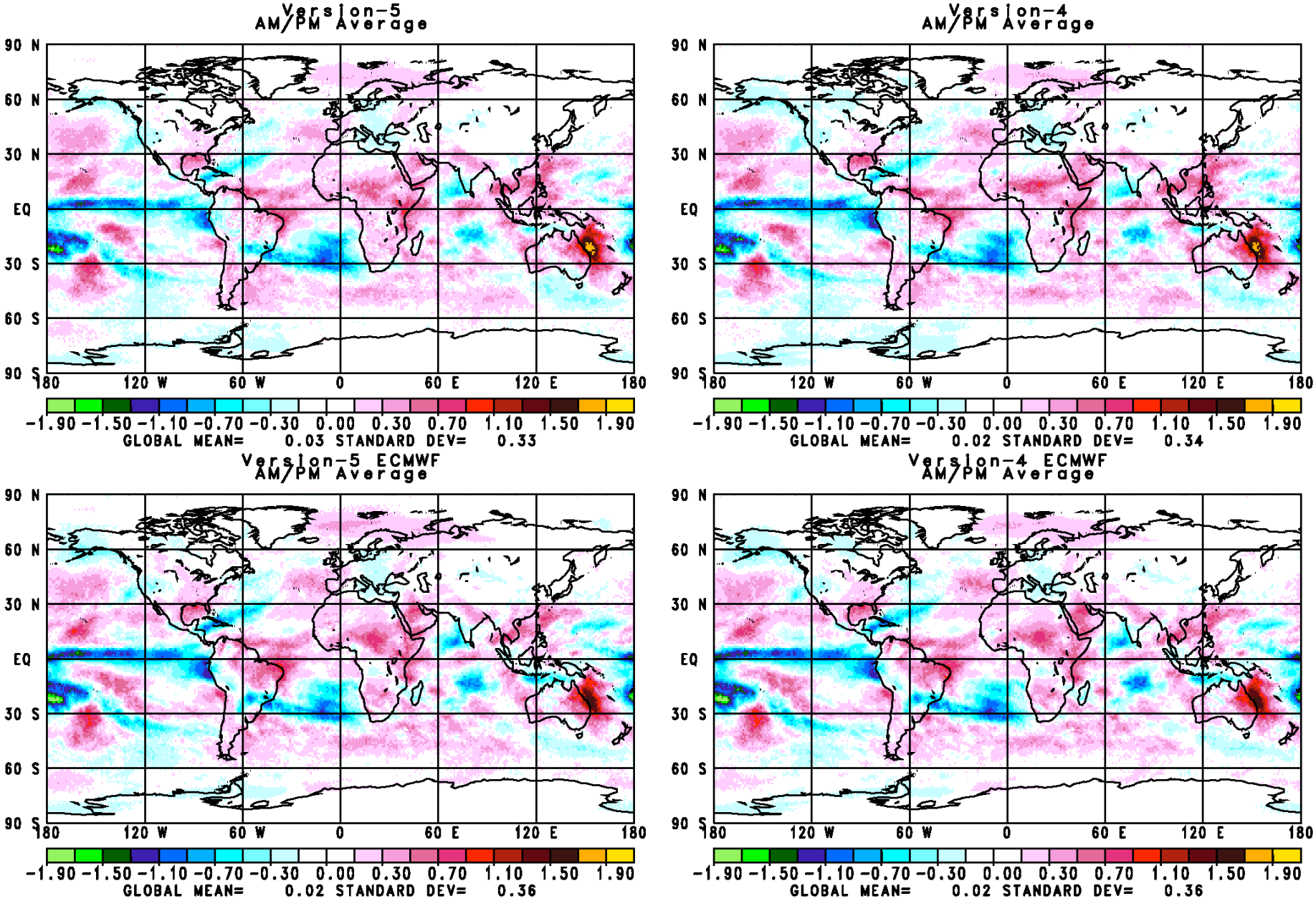




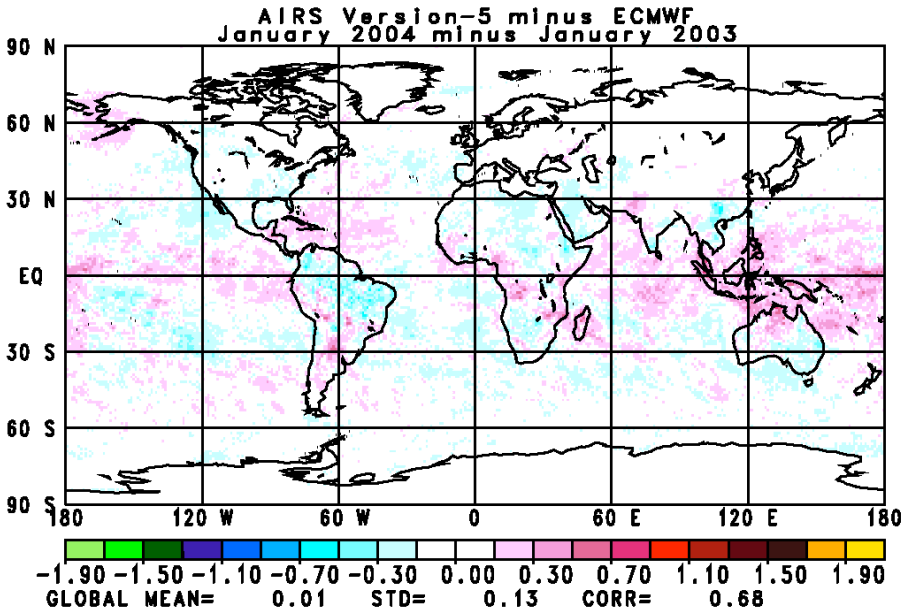


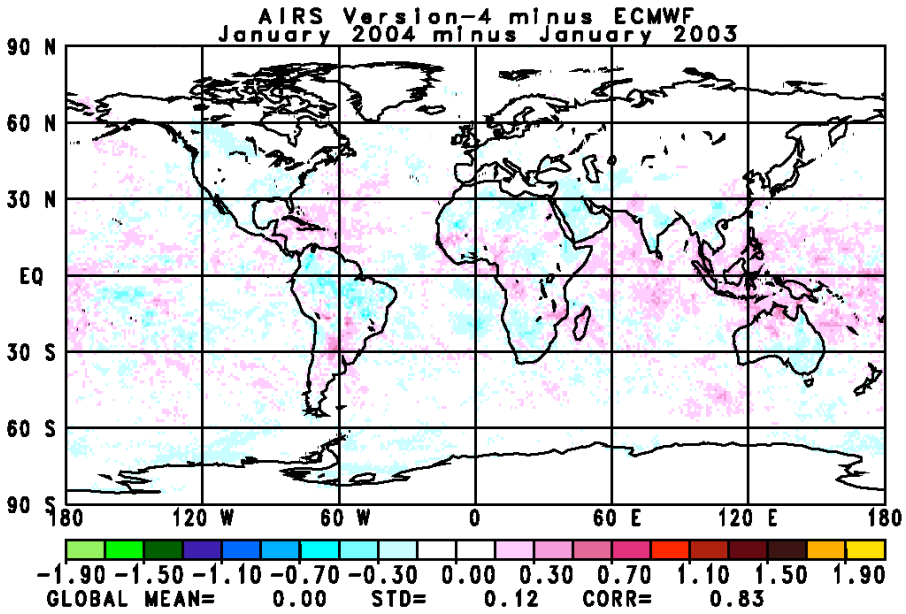


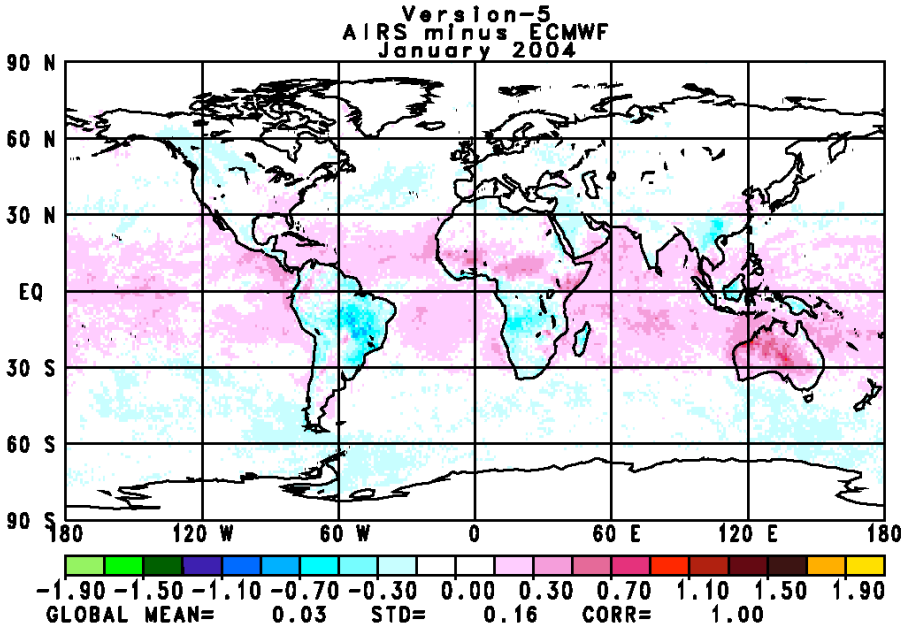
Total Precipitable Water (cm)
January 2004 minus January 2003
QC = 0 and 1

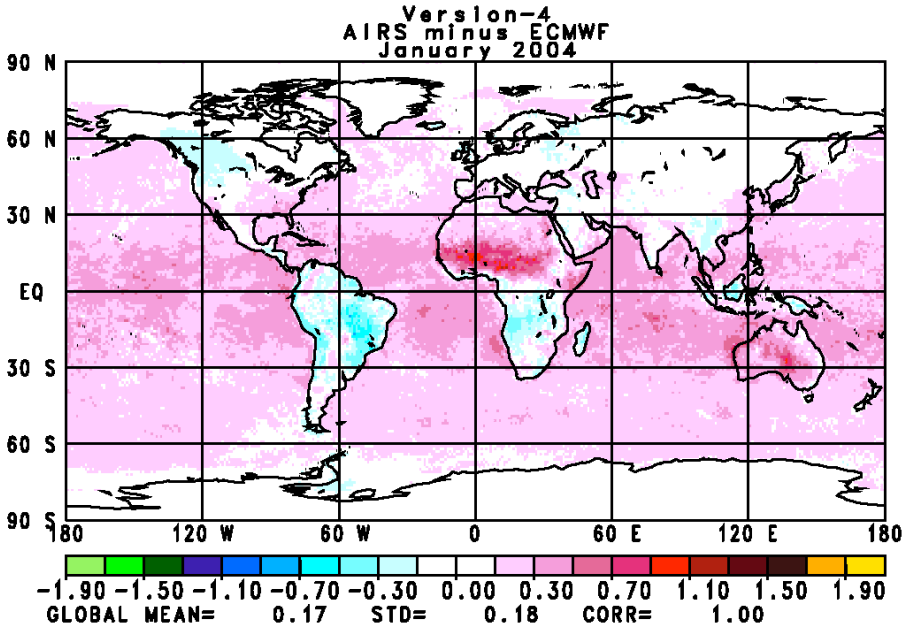


# Total Precipitable Water (cm)
QC = 0 and 1

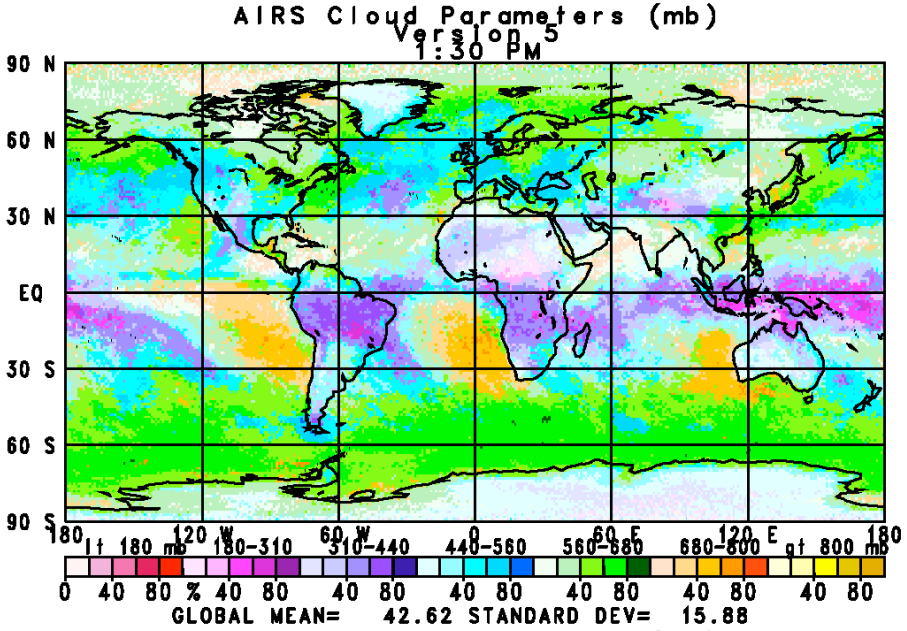


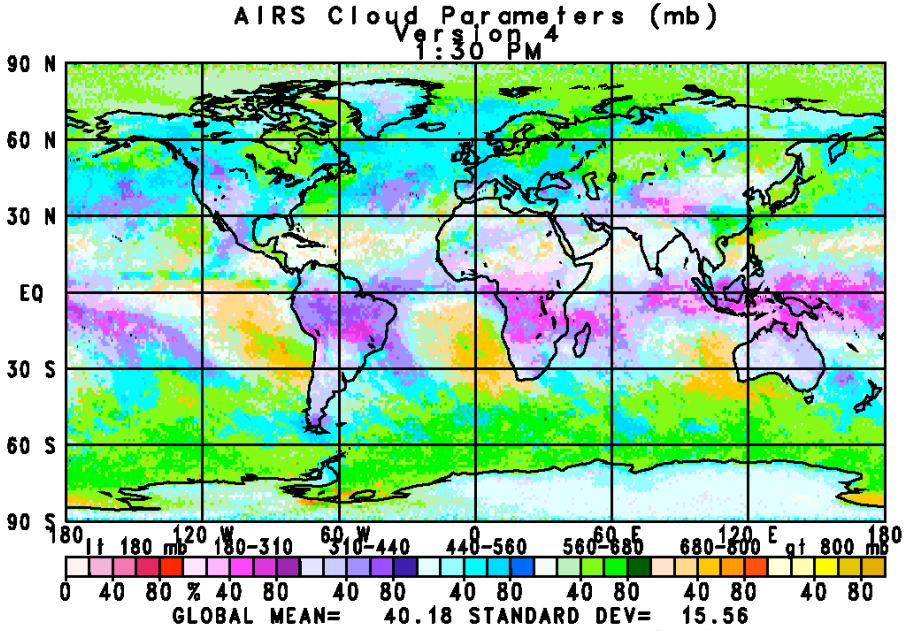


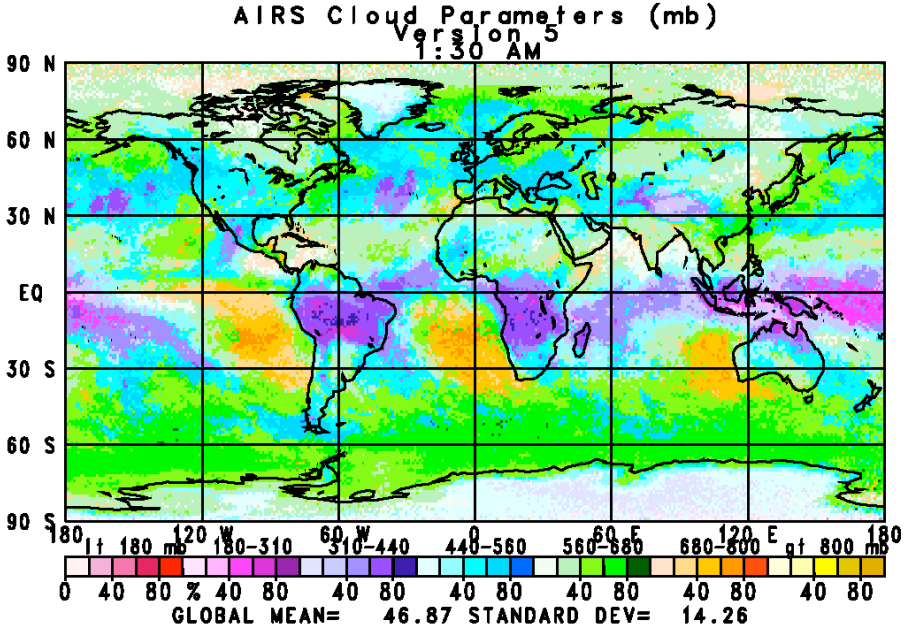


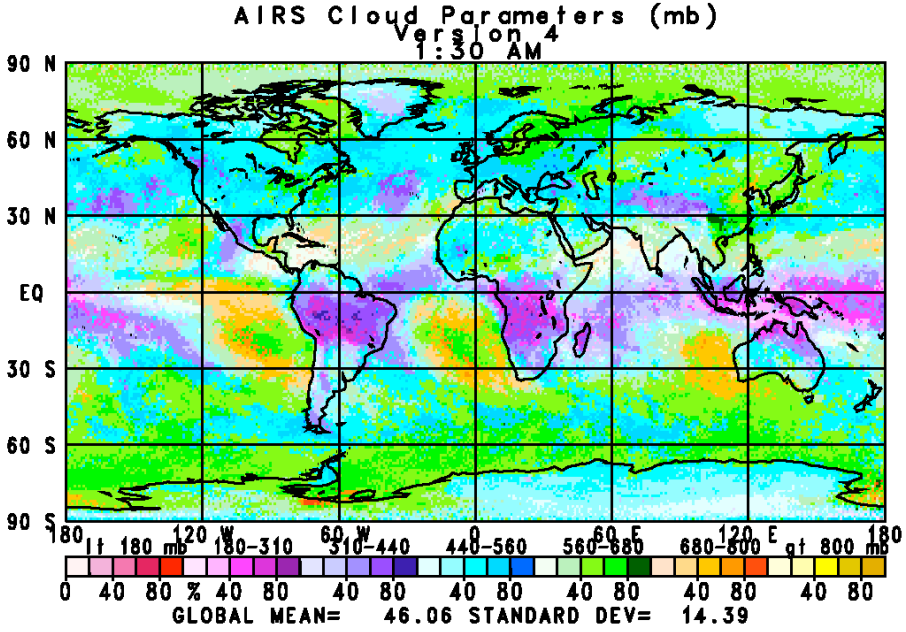


AIRS Cloud Parameters
January 2004

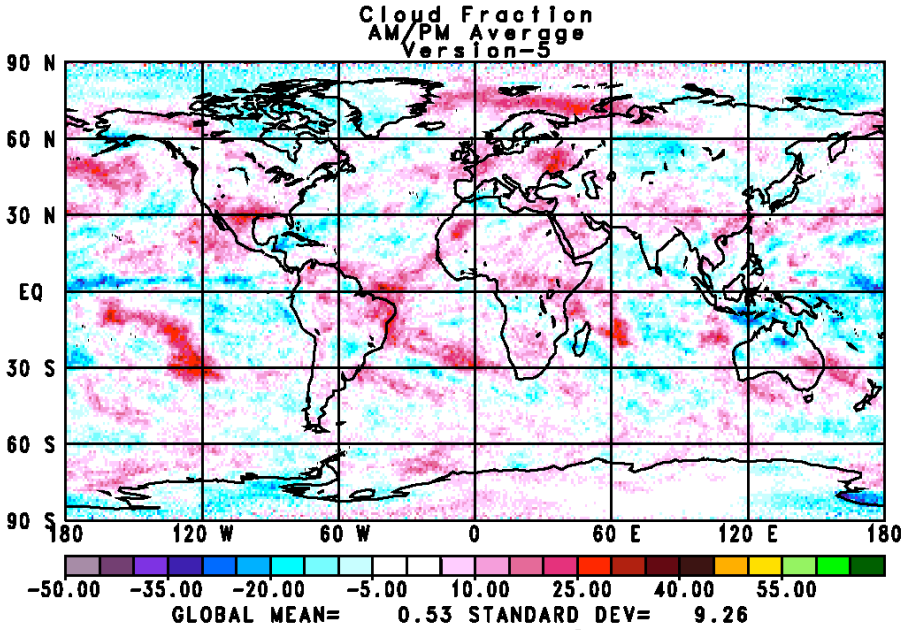


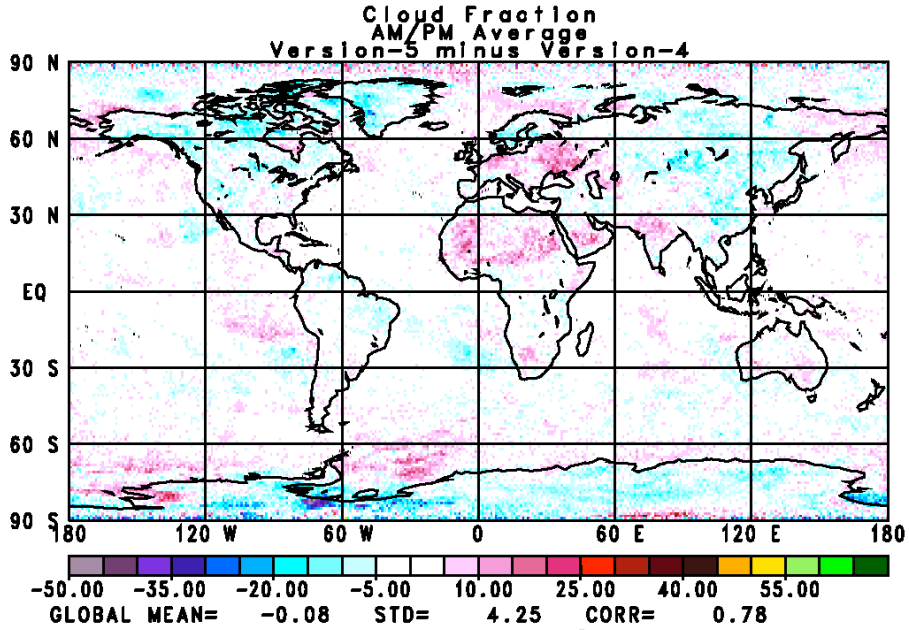


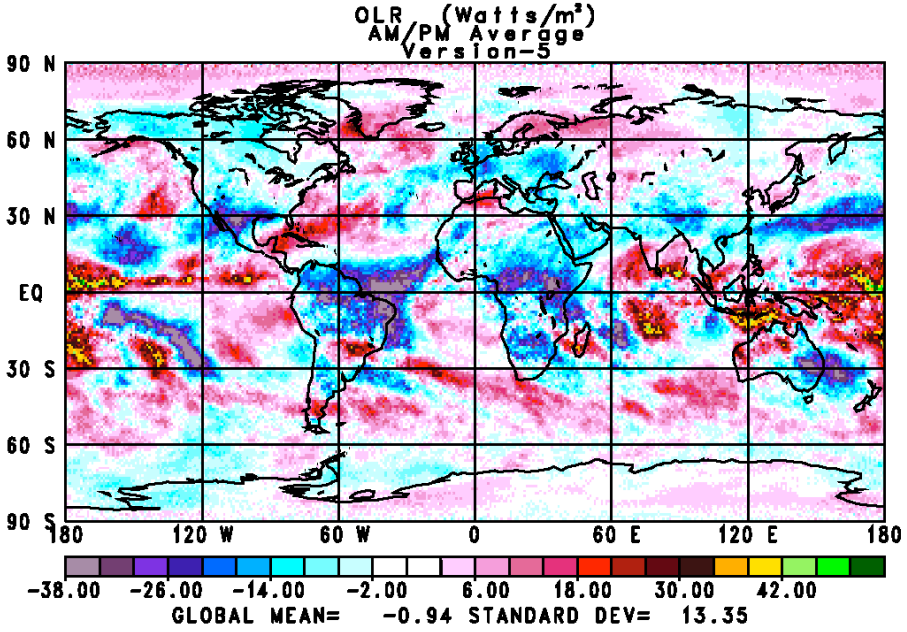


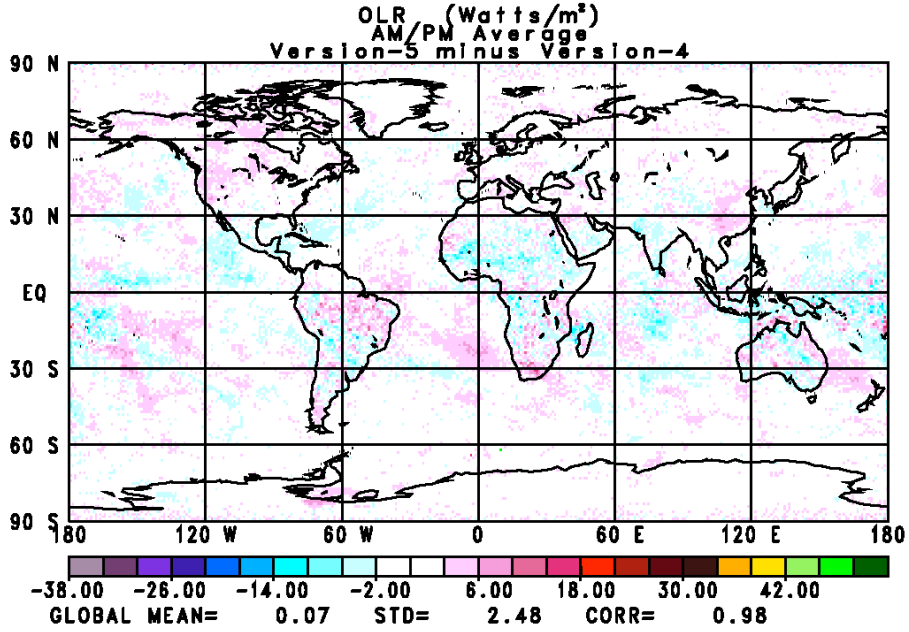


AIRS Cloud Fractions and OLR
January 2004 minus January 2003

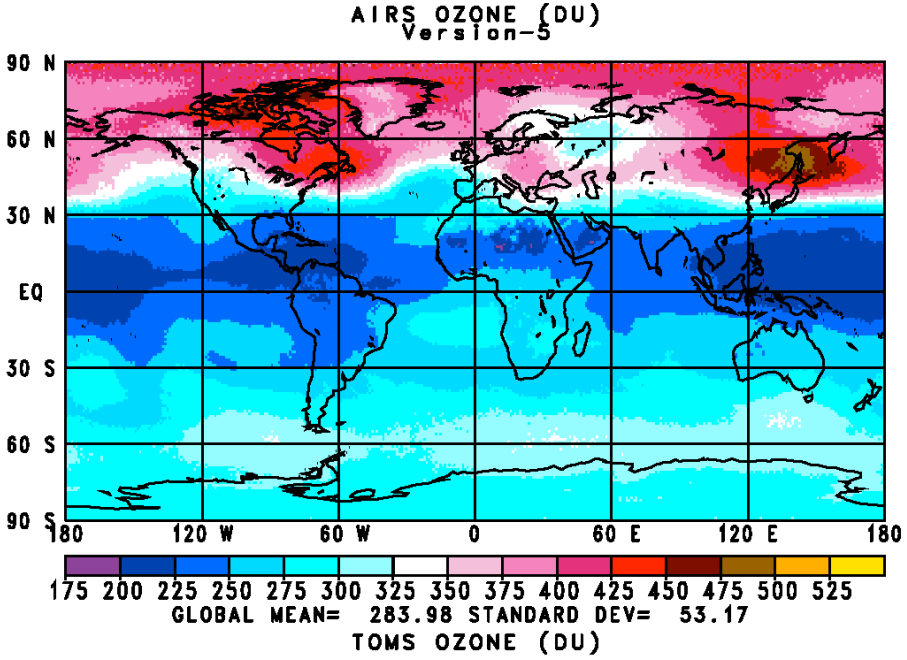


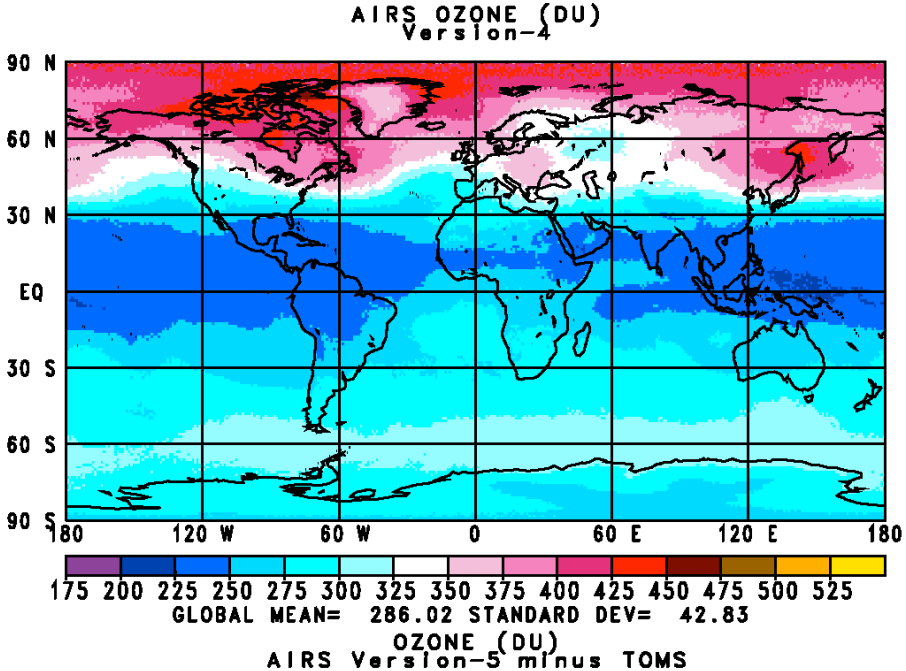


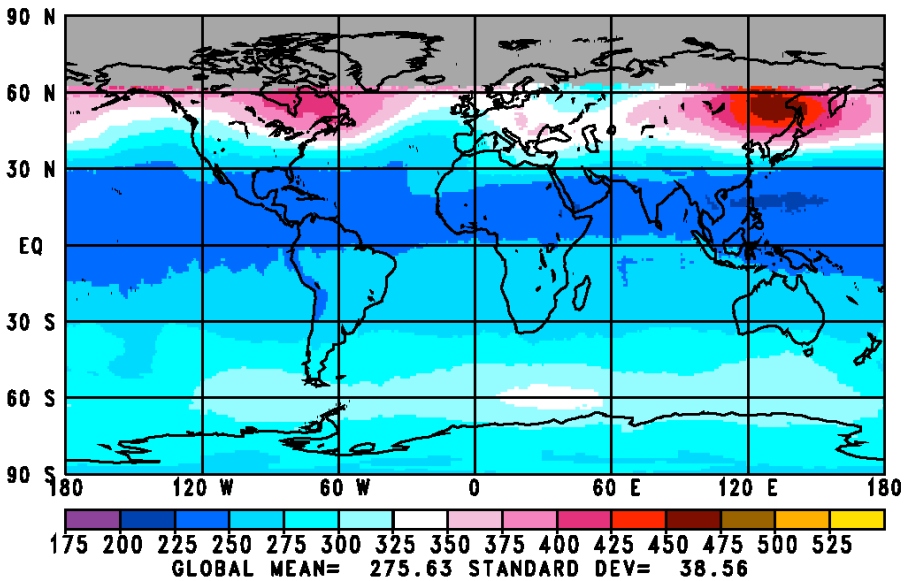


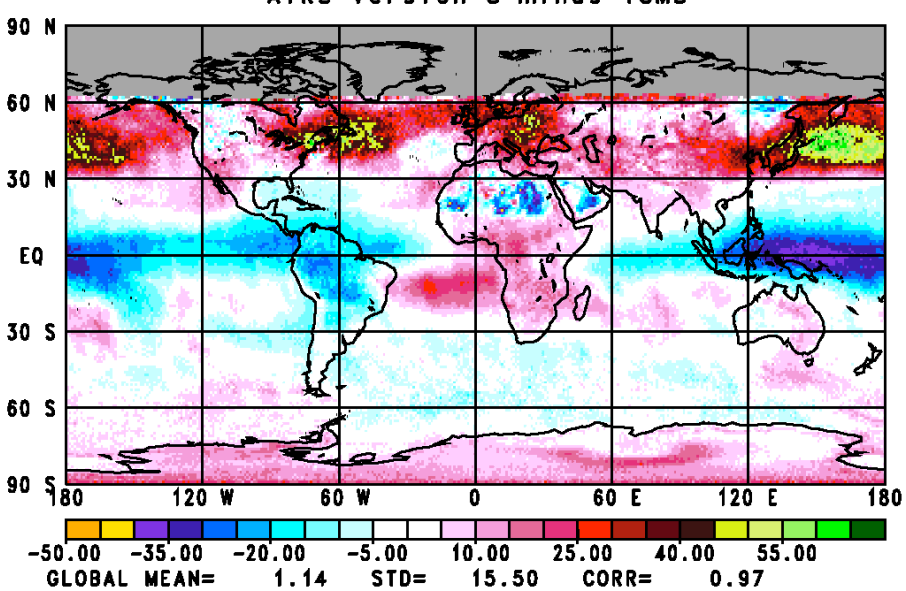


Ozone (DU)
January 2004

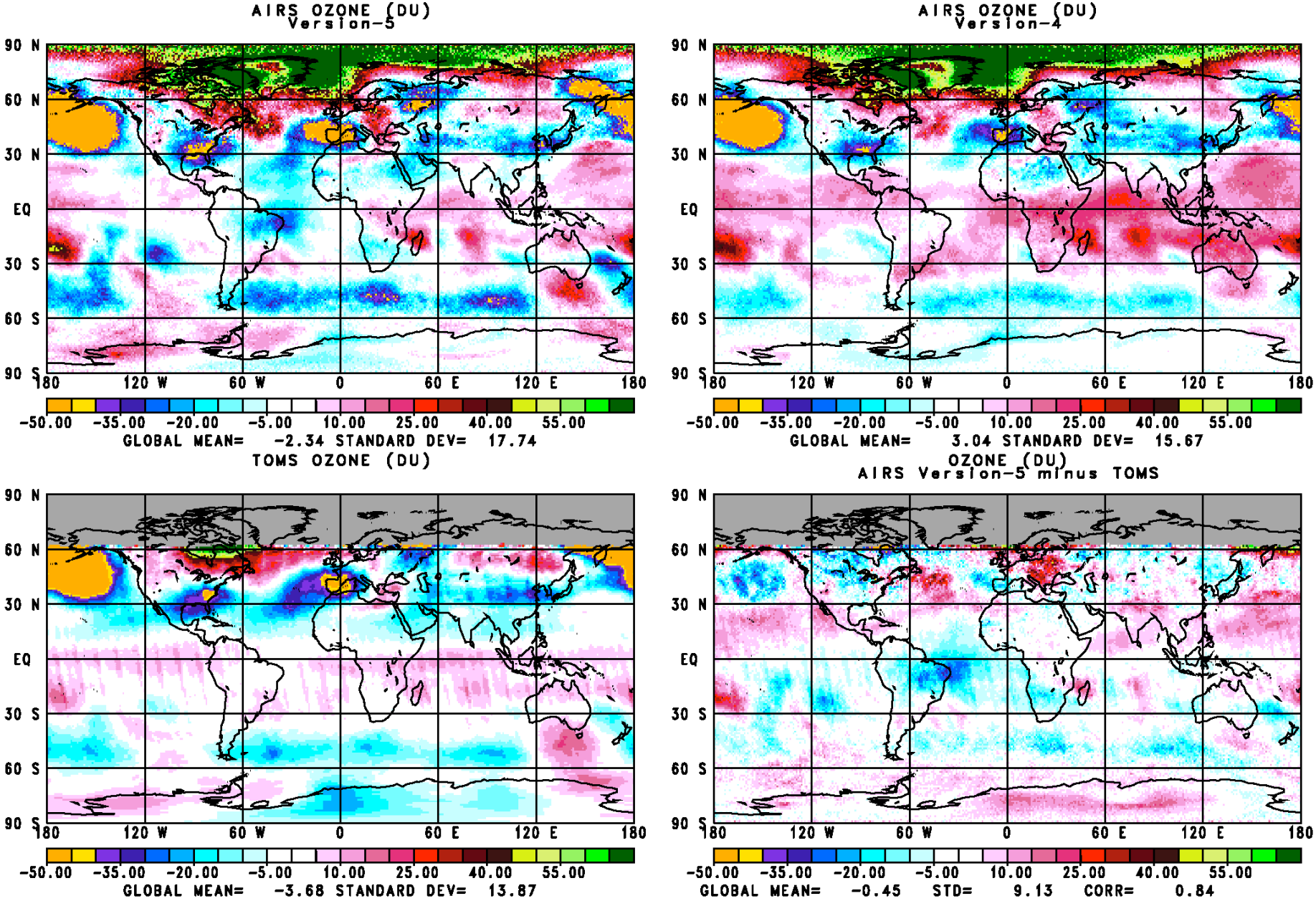








Ozone (DU)
January 2004 minus January 2003



SUMMARY

Version 5 is a considerable improvement over Version 4

Case by case error estimates are very accurate

- Allows for better quality control
- Use of error estimates in data assimilation improves forecast skill

V5 temperature soundings have higher accuracy and better spatial coverage, especially over land

V5 monthly mean temperature and moisture fields are less biased compared to ECMWF than V4

- V5 interannual monthly mean temperature differences are more spatially coherent and precise

V5 "AIRS Only" retrieval system performs very well

- Relies on use of 4 μm sounding channels and accurate error estimates
- Allows for a backup mode should AMSU fail
- Demonstrates capability of IR only sounding system - HES or ARIES

We can still do better - Here's to Version 6